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FINAL REPORT
SPACE SHUTTLE/ FOOD SYSTEM STUDY

VOLUME II - SUPPORTING APPENDICES

OVEN STUDY

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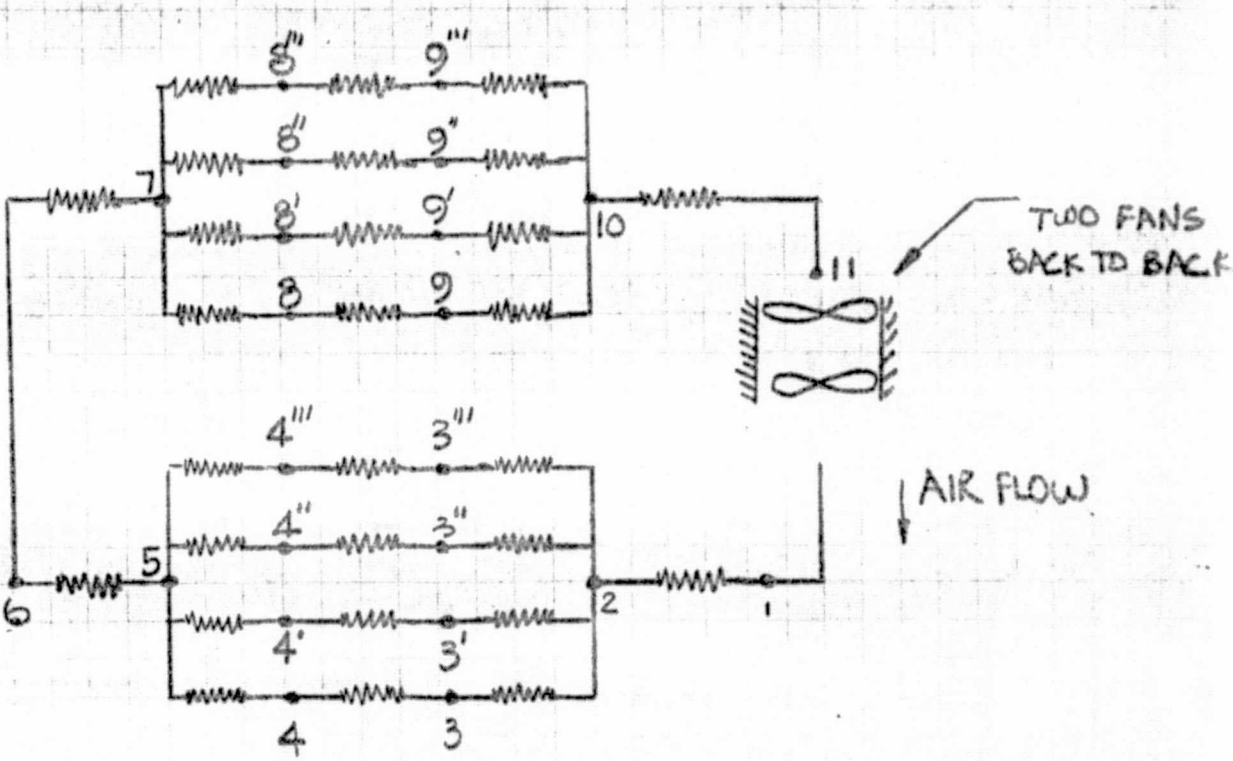
Fluid Dynamics

CONVECTION "SERIES" OVEN

EQUIVALENT AIR FLOW CIRCUIT . . . . .



(8 TRAYS)

FLOW STATION TABULATION ....

FLOW STATION	TYPE LOSS	MINIMUM FLOW AREA $(in)^2$	VELOCITY HEAD LOSS (MAX)	LOSS COEFFICIENT $\left(\frac{\text{inches of water}}{(lb/min)^2}\right)$
$\overline{12}$	90° TURN	A_{12}	1.5	K_{12}
$\overline{23}$	contraction/exp	A_{23}	1.5	K_{23}
$\overline{34}$	contraction/exp	A_{34}	1.5	K_{34}
$\overline{45}$	contraction/exp	A_{45}	1.5	K_{45}
$\overline{56}$	90° TURN	A_{56}	1.5	K_{56}
$\overline{67}$	90° TURN	A_{67}	1.5	K_{67}
$\overline{78}$	contraction/exp	A_{78}	1.5	K_{78}
$\overline{89}$	contraction/exp	A_{89}	1.5	K_{89}
$\overline{9\,10}$	contraction/exp	$A_{9\,10}$	1.5	$K_{9\,10}$
$\overline{10\,11}$	90° TURN	$A_{10\,11}$	1.5	$K_{10\,11}$
$\overline{11\,1}$	FAN(S) PRESSURE RISE		—	—

where $K \equiv 0.226 \times \text{VELOCITY HEAD LOSS} / (\text{MIN FLOW AREA})^2$

EXPLANATION OF TYPE LOSSES...

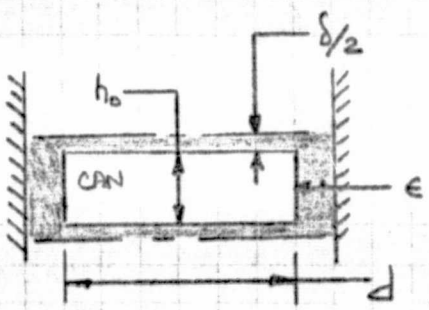
THE AIR FLOW IMPEDANCE IS DETERMINED FROM THE MOMENTUM LOSSES ASSOCIATED WITH TURNS, CONTRACTION, AND EXPANSION LOSSES. THE FRICTIONAL LOSSES ARE NEGLIGIBLE ... LESS THAN TWO PERCENT OF THE TOTAL OVEN LOSS.

THE CONTROLLING LOSSES ARE OF TWO TYPES.... 90° TURNS, WHEN EXITING AND ENTERING FOOD TRAYS; AND A CONTRACTION AND EXPANSION LOSS ASSOCIATED WITH CAN BLOCKAGE IN EACH TRAY.

THE VELOCITY HEAD LOSS USED FOR 90° TURNS IS 1.5. THIS VALUE PERTAINS TO A 90° MITRED CORNER AND IS CONSERVATIVELY USED IN THE OVEN DESIGN. THE MAXIMUM CONTRACTION VELOCITY HEAD LOSS, WHEN THE RATIO OF MINIMUM TO MAXIMUM FLOW AREA EQUALS ZERO, IS 0.5; THE MAXIMUM EXPANSION VELOCITY HEAD LOSS, WHEN THE RATIO OF MINIMUM TO MAXIMUM FLOW AREA EQUALS ZERO, IS 1.0. THE OVEN DESIGN/ANALYSIS CONSERVATIVELY USES A MAXIMUM CONTRACTION/EXPANSION VELOCITY HEAD LOSS OF 1.5.

INCLUDED IN THE DETAILED ANALYSIS IS A PRESSURE LOSS ALLOWANCE FOR HEATER FLOW IMPEDANCE.

MINIMUM FLOW AREA (PER CAN) FOR FLOW IMPEDANCE CALCULATION..



MINIMUM FLOW AREA IS SHADED!
(FOOD CAN LIP NOT SHOWN)

h_o ≡ can height

ϵ ≡ MINIMUM EFFECTIVE CAN SIDE CLEARANCE

d ≡ can diameter (CAN LIP NOT SHOWN)

$\delta/2$ ≡ MINIMUM EFFECTIVE CAN "TOP" AND "BOTTOM" CLEARANCE

(NOTE; SPACING BETWEEN CANS ~ $2(\delta/2) = \delta$)

THE MINIMUM CAN FLOW AREA IS GIVEN BY,

$$A_{MIN} = 2(\delta/2)d + 2(h_o + 2(\delta/2))\epsilon$$

$$A_{min} = \delta d + 2\epsilon(h_o + \delta)$$

WITH $d = 3.75"$ & $h_o = 1.313"$,

$$\boxed{A_{MIN} = 3.75\delta + 2\epsilon(1.313 + \delta)}$$

⊙ $\delta = 0.25"$

ϵ (in)	A_{MIN} $(in)^2$
0.125	1.33
0.25	1.72
0.375	2.12
0.500	2.50

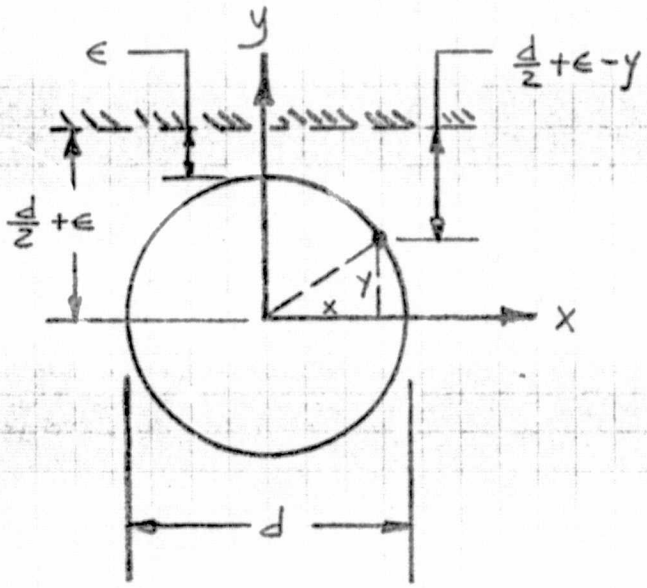
NOTE: FROM FLOW STATION TABULATION,

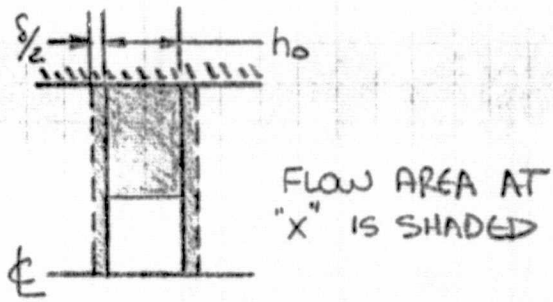
$A_{MIN} = A_{23} = A_{34} = A_{45} = A_{2'3'}$ etc.

⊙ $\delta = 0.5"$

ϵ (in)	A_{MIN} $(in)^2$
0.125	2.32
0.25	2.77
0.375	3.23
0.500	3.68

MEAN FLOW AREA (PER CAN) USED FOR COMPUTING CAN MEAN HEAT TRANSFER COEFFICIENT .....





THE FLOW AREA AT ANY X,

$$A = 2h\left\{\left(\frac{d}{2}+\epsilon\right) - \sqrt{\left(\frac{d}{2}\right)^2 - x^2}\right\} + \delta(d+2\epsilon)$$

THE MEAN FLOW AREA IS GIVEN BY,

$$A_{MEAN} = 2h\left\{\frac{1}{d/2}\int_0^{d/2}\left(\frac{d}{2}+\epsilon\right)dx - \frac{1}{d/2}\int_0^{d/2}\sqrt{\left(\frac{d}{2}\right)^2 - x^2}\,dx\right\} + \delta(d+2\epsilon)$$

$$= 2h\left\{\frac{2}{d}\left(\frac{d}{2}+\epsilon\right)x\Big|_0^{d/2} - \frac{2}{d}\left\{\frac{1}{2}\left(x\sqrt{\left(\frac{d}{2}\right)^2 - x^2} + \left(\frac{d}{2}\right)^2 \sin^{-1}\frac{x}{d/2}\right)\right\}\Big|_0^{d/2}\right\}$$

$+ \delta(d+2\epsilon)$

after simplification,

$$A_{MEAN} = 2h\left(0.215\,\frac{d}{2} + \epsilon\right) + \delta(d + 2\epsilon)$$

(a) $\delta = 0.25"$

$$A_{MEAN} = 2(1.313)\left(0.215 \times \frac{3.75}{2} + \epsilon\right) + 0.25(3.75 + 2\epsilon)$$

$$A_{MEAN} = 2 + 3.13\epsilon$$

ϵ (in)	A_{MEAN} $(in)^2$	$4A_{MEAN}$ $(in)^2$
0.125	2.39	9.56
0.250	2.78	11.10
0.375	3.17	12.70
0.500	3.57	14.26

NOTE: $4A_{MEAN}$ ≡ MEAN FLOW AREA THRU FOUR PARALLEL CONNECTED (WITH RESPECT TO AIR-FLOW) FOOD TRAYS.

② $\delta = 0.5''$

$$A_{MEAN} = 2(1.313)\left(0.25 \times \frac{3.75}{2} + \epsilon\right) + 0.5(3.75 + 2\epsilon)$$

$$A_{MEAN} = 2.93 + 3.626\epsilon$$

ϵ in	A_{MEAN} (in^2)	$4A_{MEAN}$ (in^2)
0.125	3.38	13.52
0.250	3.84	15.36
0.375	4.29	17.16

PRESSURE DROP ESTIMATE FOR... $\delta = 0.25"$ & $\epsilon = 0.125"$

NOTE: AS A CONSERVATIVE ESTIMATE, THE CAN MINIMUM FLOW AREA IS USED WHEN COMPUTING 90° TURN LOSSES. THE RATIONALE FOR THIS PROCEDURE IS BASED ON VELOCITY HEAD LOSS DATA THAT CORRELATES TURN PRESSURE LOSS COEFFICIENTS WITH MINIMUM AREA WHEN THE INLET TURN VELOCITY IS NOT EQUAL TO THE EXITING TURN VELOCITY.

THEREFORE, @ $\delta = 0.25"$, $\epsilon = 0.125"$

$$A_{23} = A_{34} = A_{45} = A_{18} = A_{89} = A_{910} = 1.33 in^2$$

$$A_{12} = A_{56} = A_{67} = A_{1011} = 5.32 in^2$$

$$K_{12} = K_{56} = K_{67} = K_{1011} = \frac{0.226 \times 1.5}{(5.32)^2} = 0.012 \text{ "}H_2O/(lb/min)^2$$

$$\left.\begin{aligned} K_{23} &= K_{23'} = K_{23''} = K_{23'''} \\ K_{34} &= K_{34'} = K_{3''4''} = K_{3'''4'''} \\ K_{45} &= K_{4'5} = K_{4''5} = K_{4'''5} \end{aligned}\right\} \text{ all equal to } = \frac{0.226 \times 1.5}{(1.33)^2} = 0.1916 \text{ "}H_2\text{O}/(lb/min)^2$$

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OF POOR QUALITY

THRU PATH $\overline{2345}$

$$K_{\overline{2345}} = K_{23} + K_{34} + K_{45} = 0.5748$$

$$\dagger\ K_{\overline{2345}} = K_{\overline{23''4''5}} = K_{\overline{23'''4'''5}} = 0.5748$$

THE EFFECTIVE LOSS COEFFICIENT FOR ALL 4 PARALLEL CONNECTED FOOD TRAYS .....

$$\frac{1}{\sqrt{K_{2345}}_{EFF}} = \frac{1}{\sqrt{K_{2345}}} + \frac{1}{\sqrt{K_{234'5}}} + \frac{1}{\sqrt{K_{23''4''5}}} + \frac{1}{\sqrt{K_{23'''4'''5}}}$$

$$= \frac{4}{\sqrt{K_{\overline{2345}}}}$$

OR

$$K_{\overline{2345}}_{EFF} = \frac{K_{\overline{2345}}}{16} \cong 0.036\ "H_2O/(lb/min)^2$$

BY SIMILARITY ..... $K_{\overline{7891 0}}_{EFF} = 0.036\ "H_2O/(lb/min)^2$

∴ THE TOTAL SYSTEM LOSS COEFFICIENT .....

$$\mathbb{K}_{SYS} = \sum K = K_{12} + K_{2345}_{EFF} + K_{56} + K_{67} + K_{7891 0}_{EFF} + K_{10,}$$

$$\mathbb{K}_{SYS} = 0.12\ "H_2O/(lb/min)^2$$

A HEATER LOSS COEFFICIENT OF $0.01\ "H_2O/(lb/min)^2$ IS INCLUDED.

THEREFORE, $\mathbb{K}_{\substack{SYSTEM \\ TOTAL}} = 0.12 + 0.01 = 0.13$

THE TOTAL OVEN FLOW IMPEDANCE IS GIVEN BY,

$$\sigma \Delta P = \mathbb{K}_{\substack{SYSTEM \\ TOTAL}} \omega^2 , "H_2O$$

where, $\sigma = \dfrac{\rho_{ACTUAL}}{0.0765}$ (density ratio)

@ 180°F, $\rho_{ACTUAL} = \dfrac{P}{RT} = \dfrac{14.7 \times 144}{53.3 \times 640} = 0.062 \dfrac{lb}{ft^3}$

$$\sigma = \frac{0.062}{0.0765} = 0.81$$

ΔP = SYSTEM PRESSURE LOSS, $"H_2O$

ω = RECIRCULATED AIR FLOW RATE, lb/min (TOTAL)

$\omega = \rho_{ACTUAL} \times CFM$

$$\Delta P = \frac{0.13}{0.81} \omega^2 = 0.16 \omega^2 \ "H_2O$$

$\delta = 0.25 + \epsilon = 0.125$

CFM	25	50	75	100
ω, lb/min	1.55	3.1	4.65	6.2
ΔP, $"H_2O$	0.384	1.54	3.46	6.15

① $\delta = 0.25"$ & $\epsilon = 0.25$

$$\mathbb{K}_{\substack{\text{SYSTEM}\\\text{TOTAL}}} = \mathbb{K}_{\substack{\text{SYSTEM}\\@\epsilon=0.125}} \left(\frac{A_{\text{MIN}\,@\,\epsilon=.125"}}{A_{\text{MIN}\,@\,\epsilon=0.250"}} \right)^2 + .01$$

$$\mathbb{K}_{\substack{\text{SYSTEM}\\\text{TOTAL}}} = 0.12\left(\frac{1.33}{1.72}\right)^2 + .01 \cong 0.082 \text{"H}_2\text{O}/(\text{lb/min})$$

$$\Delta P = \frac{\mathbb{K}_{\substack{\text{SYSTEM}\\\text{TOTAL}}}}{\sigma}\,\omega^2 = \frac{.082}{0.81}\,\omega^2 = 0.101\,\omega^2$$

$\delta = .25"$ & $\epsilon = 0.25"$

CFM	25	50	75	100
ΔP, "H_2O	0.243	0.971	2.18	3.88

② $\delta = 0.25"$ & $\epsilon = 0.375"$

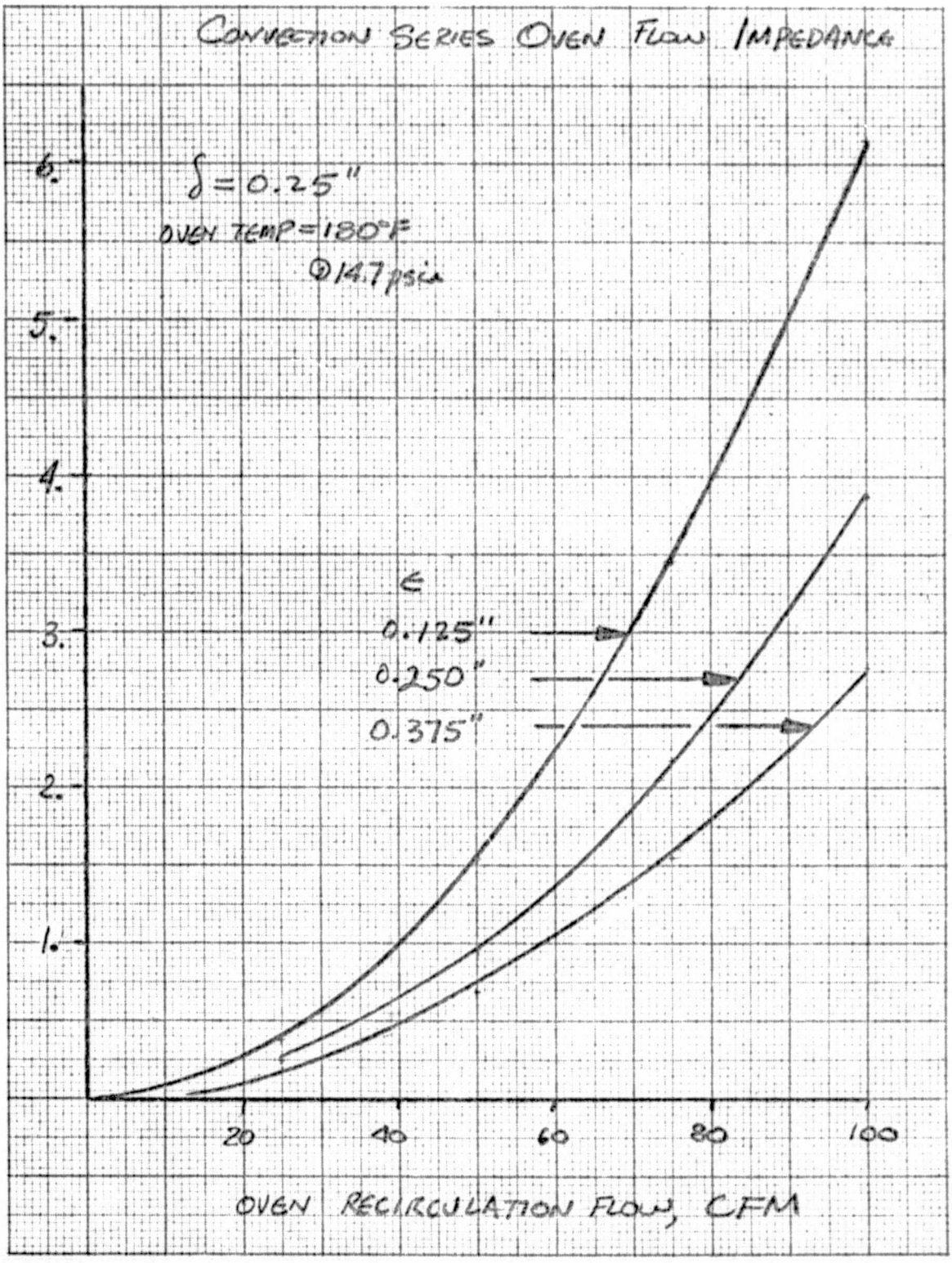
$$\mathbb{K}_{\substack{\text{SYSTEM}\\\text{TOTAL}}} = \mathbb{K}_{\substack{\text{SYSTEM}\\@\epsilon=.125"}} \left(\frac{A_{\text{MIN}\,@\,\epsilon=.125"}}{A_{\text{MIN}\,@\,\epsilon=.375"}} \right)^2 + .01$$

$$= 0.12\left(\frac{1.33}{2.12}\right)^2 + .01 = 0.0572$$

$$\Delta P = \frac{0.0572}{0.81}\,\omega^2 = .071\,\omega^2$$

$\delta = 0.25"$ & $\epsilon = .375"$

CFM	25	50	75	100
ΔP, "H_2O	0.171	0.682	1.54	2.73



HEAT TRANSFER COEFFICIENT ESTIMATE ...

IN ORDER TO ESTIMATE THE FOOD CAN HEAT TRANSFER COEFFICIENT, A SIMPLIFIED, BUT CONSERVATIVE CALCULATION PROCEDURE IS USED. THE COMPUTATION PROCEDURE IS BASED ON THE FOLLOWING CORRELATION ....

$$\frac{h}{\sqrt{\sigma}} = 1.46 + 0.23V \text{ , BTU/hr ft}^2\text{°F}$$

where h = heat transfer coefficient, BTU/hr ft²°F

$\sigma = S_{ACTUAL}/.0765$

V = air velocity, ft/sec

DESCRIBED IN WADC TECH REPORT 55-254, JUNE 1955.

ABOVE EQUATION CAN ALSO BE EXPRESSED AS,

$$\frac{h}{\sqrt{\sigma}} = 1.46 + 0.23 \frac{CFM \times 144}{60(4A_{MEAN})}$$

WHERE CFM ~ AIR FLOW

$4A_{MEAN}$ ~ in²

$$\boxed{\frac{h}{\sqrt{\sigma}} = 1.46 + 0.552 \frac{CFM}{(4A_{MEAN})}}$$

Note.

① 14.7 psia & 180F $\quad \sigma = 0.81$

$\sqrt[4]{\sigma} = 0.9$

② 13.7 psia & 180F

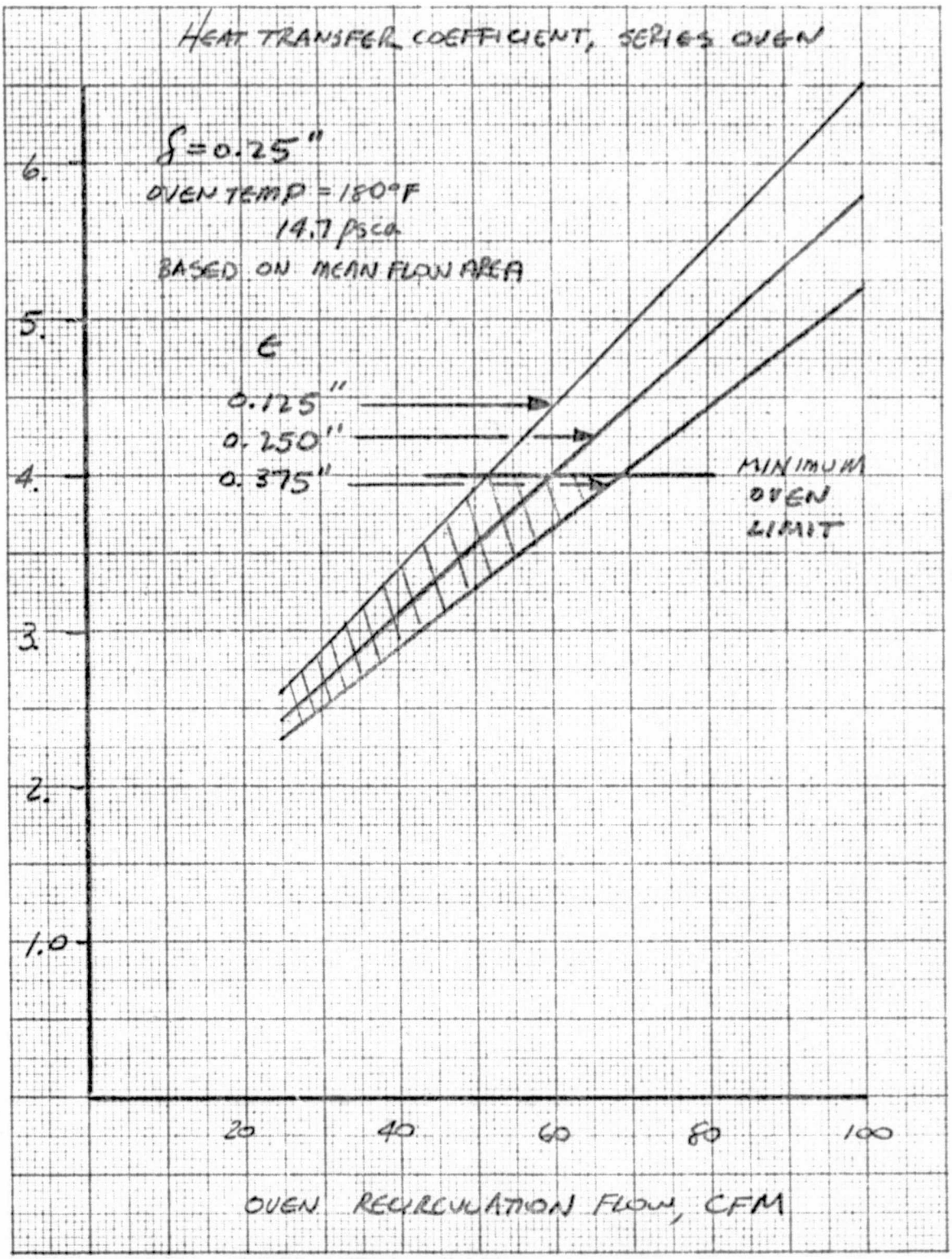
$\sigma = 0.756$

$\sqrt[4]{\sigma} = 0.87$

AT A CABIN PRESSURE OF 13.7 psia, the HEAT TRANSFER COEFFICIENT (AT THE SAME VOLUMETRIC FLOW) IS REDUCED BY ONLY 3.3%.

①14.7psia & 180°F

δ (in)	ϵ (in)		CFM 25	50	75	100
0.25	0.125	$h/\sqrt{\sigma}$	2.90	4.34	5.79	7.23
	($4A_{MEAN}$ = 9.56)	h	2.61	3.91	5.21	6.51
0.25	0.25	$h/\sqrt{\sigma}$	2.70	3.95	5.19	6.43
	($4A_{MEAN}$ = 11.1 in²)	h	2.43	3.56	4.67	5.79
0.25	0.375	$h/\sqrt{\sigma}$	2.55	3.63	4.72	5.8
	($4A_{MEAN}$ = 12.7 in²)	h	2.30	3.27	4.25	5.22



REQUIRED FAN POWER...

$$HP = \frac{\Delta P \times CFM}{6346\,\eta_o}$$

ΔP ~ PRESSURE DROP, "H_2O

η_o ~ OVERALL FAN EFFICIENCY

FOR THE FAN CAPACITIES CONSIDERED IN THE OVEN DESIGN, THE OVERALL FAN EFFICIENCY IS APPROXIMATELY 30%.

INPUT

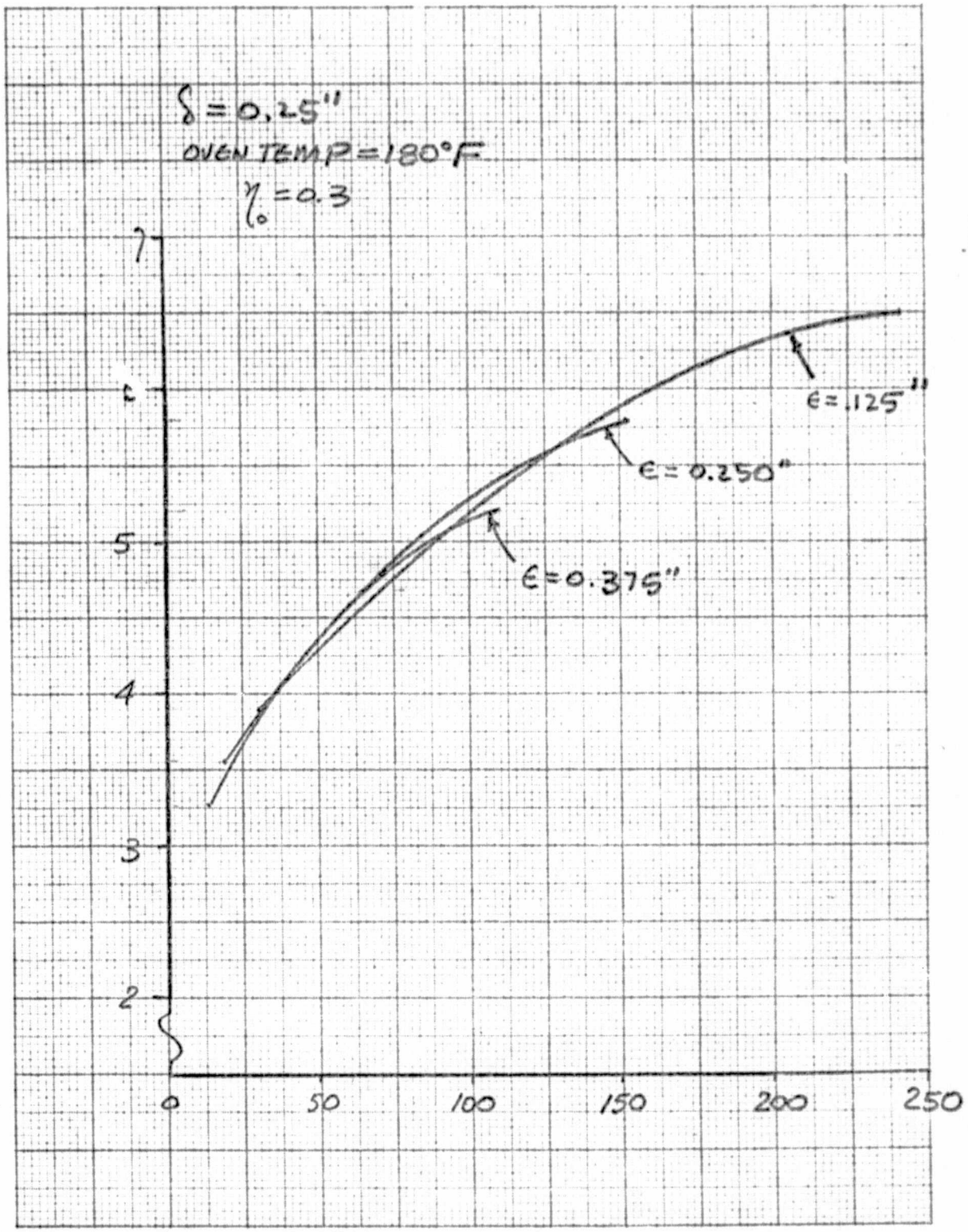
$$HP = \frac{\Delta P\ CFM}{6346 \times 0.3} = \frac{\Delta P\ CFM}{1903.8}$$

$$WATTS \cong \frac{\Delta P\ CFM}{1903.8}\ 0.75 \times 10^3 = 0.394\,\Delta P\,CFM$$

$\therefore$ INPUT POWER = $0.394\,\Delta P\ CFM$, WATTS

@ $\delta = 0.25"$

ϵ	CFM	25	50	75	100
0.125"	h_{MEAN} $\frac{BTU}{hr\,ft^2\,°F}$	2.61	3.91	5.21	6.51
	ΔP, "H_2O	0.384	1.54	3.46	6.15
	INPUT POWER, WATTS	3.78	30.3	102.2	242.3
0.250"	h_{MEAN} $\frac{BTU}{hr\,ft^2\,°F}$	2.43	3.56	4.67	5.79
	ΔP, "H_2O	0.243	0.971	2.18	3.88
	INPUT POWER, WATTS	2.39	19.1	64.4	152.9
0.375	h_{MEAN} $\frac{BTU}{hr\,ft^2\,°F}$	2.3	3.27	4.25	5.22
	ΔP, "H_2O	0.171	0.682	1.54	2.73
	INPUT POWER, WATTS	1.68	13.4	45.5	107.6

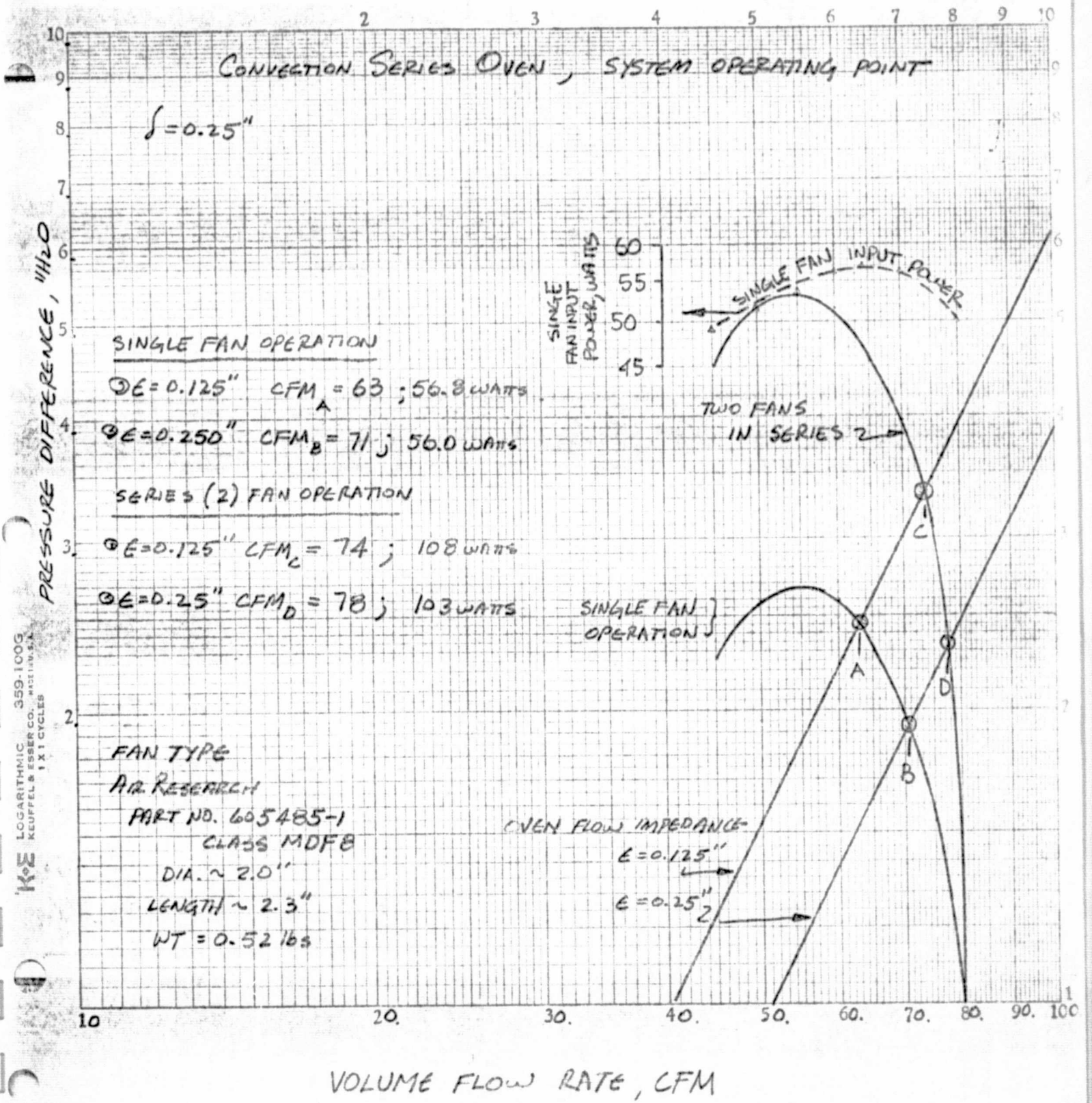


THE FOLLOWING FAN INPUT POWER LEVELS ARE REQUIRED TO ACHIEVE FOOD CAN HEAT TRANSFER COEFFICIENTS ...

① $\delta = 0.25"$ & $\epsilon = 0.125"$

h BTU/HR FT^2 F	TOTAL FAN INPUT POWER* WATTS
4.0	35.0
4.5	63.0
5.0	90.0
5.5	122.0
6.0	160.0

*BASED ON FAN EFF = 0.3



@ $\delta = 0.25"$ & $\epsilon = 0.125"$ WITH ACTUAL FAN PERFORMANCE

SINGLE FAN

@ CFM = 63 CFM $h = 4.6$ BTU/HR FT^2 °F
INPUT POWER = 56.8 WATTS

TWO SERIES FANS

@ CFM = 74 CFM $h = 5.15$ BTU/hr ft^2 °F
INPUT POWER = 108 WATTS

@ $\delta = 0.25"$ & $\epsilon = 0.25"$

SINGLE FAN

@ CFM = 71 $h = 4.5$ BTU/HR FT^2 °F
INPUT POWER = 56.0 WATTS

TWO SERIES FANS

@ CFM = 78 $h = 4.8$ BTU/HR FT^2 °F
INPUT POWER = 103 WATTS

NOTE: FOR $\epsilon = 0.125"$ A 90% INCREASE IN FAN POWER RESULTS IN ONLY A 12% INCREASE IN HEAT TRANSFER COEFFICIENT.

OVEN DESIGN FOR $\delta = 0.5"$

$$A_{MIN} = 3.75\delta + 2\epsilon(1.313 + \delta)$$

ϵ (in)	A_{MIN} (in^2)	$4\,A_{MEAN}$ (in^2)
0.125	2.32	13.52
0.250	2.77	15.36
0.375	3.23	17.16

PRESSURE DROP DETERMINATION ....

@ $\epsilon = .125$,

$$A_{23} = A_{34} = A_{45} = A_{78} = A_{89} = A_{9,10} = 2.32\ in^2$$

$$A_{12} = A_{56} = A_{67} = A_{10,11} = 9.28\ in^2$$

$$K_{12} = K_{56} = K_{67} = K_{10,11} = \frac{0.226 \times 1.5}{(9.28)^2} = 0.00394 \frac{"H_2O}{(lb/min)^2}$$

$$\left.\begin{aligned} K_{23} &= K_{2'3'} = K_{2''3''} = K_{2'''3'''} \\ K_{34} &= K_{3'4'} = K_{3''4''} = K_{3'''4'''} \\ K_{45} &= K_{4'5'} = K_{4''5''} = K_{4'''5'''} \end{aligned}\right\} \text{ALL EQUAL TO} = \frac{0.226 \times 1.5}{(2.32)^2} = 0.063$$

THRU PATH $\overline{2345}$

$$K_{\overline{2346}} = K_{23} + K_{34} + K_{45} = 0.189$$

$$\therefore K_{\overline{23'4'5}} = K_{\overline{23''4''5}} = K_{\overline{23'''4'''5}} = 0.189$$

$$K_{2345\ EFF} = \frac{K_{\overline{2345}}}{16} = 0.0118\ "H_2O/(lb/min)^2$$

$$\therefore \Sigma K_{SYS} = \Sigma K = K_{12} + K_{\overline{2345}\ EFF} + K_{56} + K_{67} + K_{78910} + K_{10}$$

$$\Sigma K_{SYS} = .0394\ \frac{"H_2O}{(lb/min)^2}$$

A HEATER LOSS COEFFICIENT OF $0.1\ "H_2O/(lb/min)^2$ IS INCLUDED...

THEREFORE, $\Sigma K_{SYSTEM\ TOTAL} = .0394 + .01 = .0494$

THE TOTAL OVEN FLOW IMPEDANCE IS GIVEN BY,

$$\sigma \Delta P = \Sigma K_{SYSTEM\ TOTAL}\ \omega^2,\ "H_2O$$

@ $\sigma = 0.81$ (180F & 14.7 psia)

$$\Delta P = \frac{0.0494}{0.81}\ \omega^2 = 0.061\omega^2,\ "H_2O$$

• $\delta = 0.5"$ & $\epsilon = 0.125"$

CFM	50	75	100	150
ω, lb/min	3.1	4.65	6.2	9.3
ΔP, "H_2O	0.586	1.32	2.34	5.28

⊙ $\delta = 0.5"$ & $\epsilon = 0.25"$

$$K_{SYSTEM\ TOTAL} = K_{SYSTEM\ @\epsilon=0.125} \left[\frac{A_{MIN\ @\epsilon=.125}}{A_{MIN\ @\epsilon=0.25}}\right]^2 + .01$$

$$K_{SYSTEM\ TOTAL} = .0394 \left(\frac{2.32}{2.77}\right)^2 + .01 = .0376$$

$$\Delta P = \frac{0.0376}{0.81} \omega^2 = 0.0464 \omega^2, \text{ "}H_2O$$

⊙ $\delta = 0.5"$ & $\epsilon = .25"$

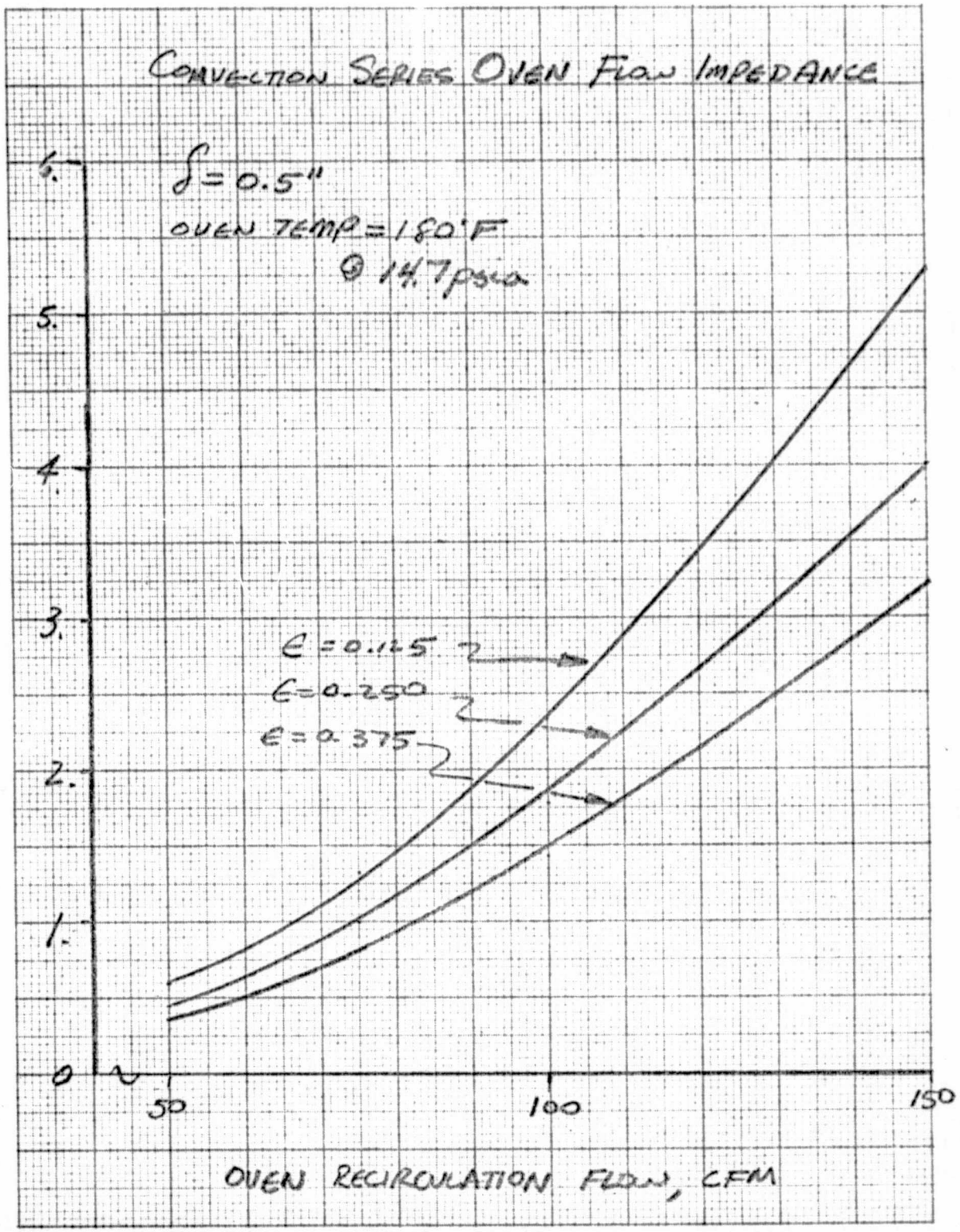
CFM	50	75	100	150
ΔP, "H_2O	0.446	1.00	1.78	4.01

@ $\delta = 0.5"$ & $\epsilon = 0.375"$

$$K_{\substack{SYSTEM \\ TOTAL}} = .0394 \left(\frac{2.32}{3.23}\right)^2 + .01 = 0.03 \text{ "H}_2\text{O/(lb/min)}$$

$$\Delta P = \frac{0.03}{0.81} \omega^2 = 0.0374 \omega^2, \text{ "H}_2\text{O}$$

CFM	50	75	100	150
ΔP, "H$_2$O	0.359	0.809	1.44	3.23

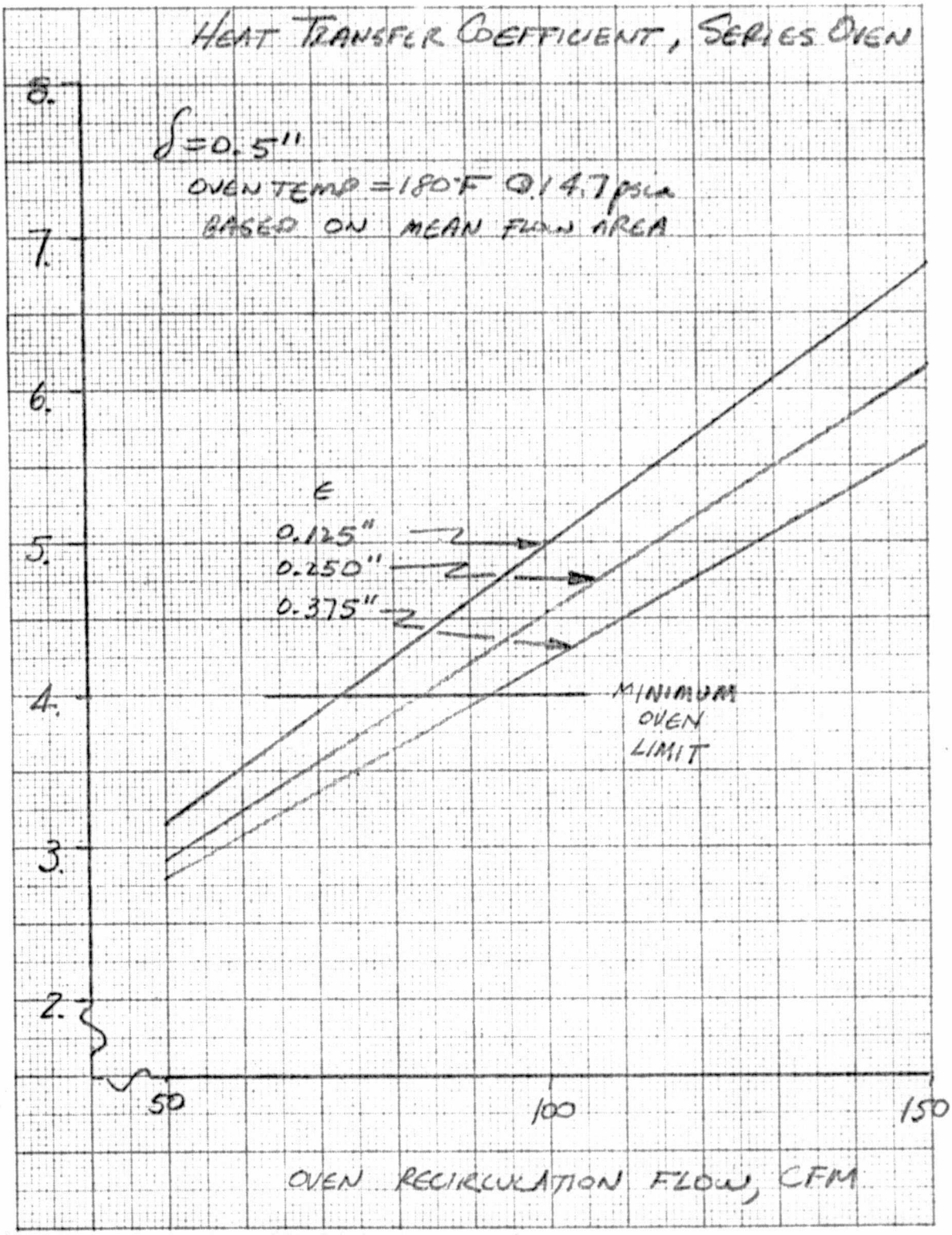


HEAT TRANSFER COEFFICIENT ESTIMATE ....

AS BEFORE,

$$\frac{h}{\sqrt{\epsilon}} = 1.46 + \frac{0.552\,CFM}{(4A_{MEAN})}$$

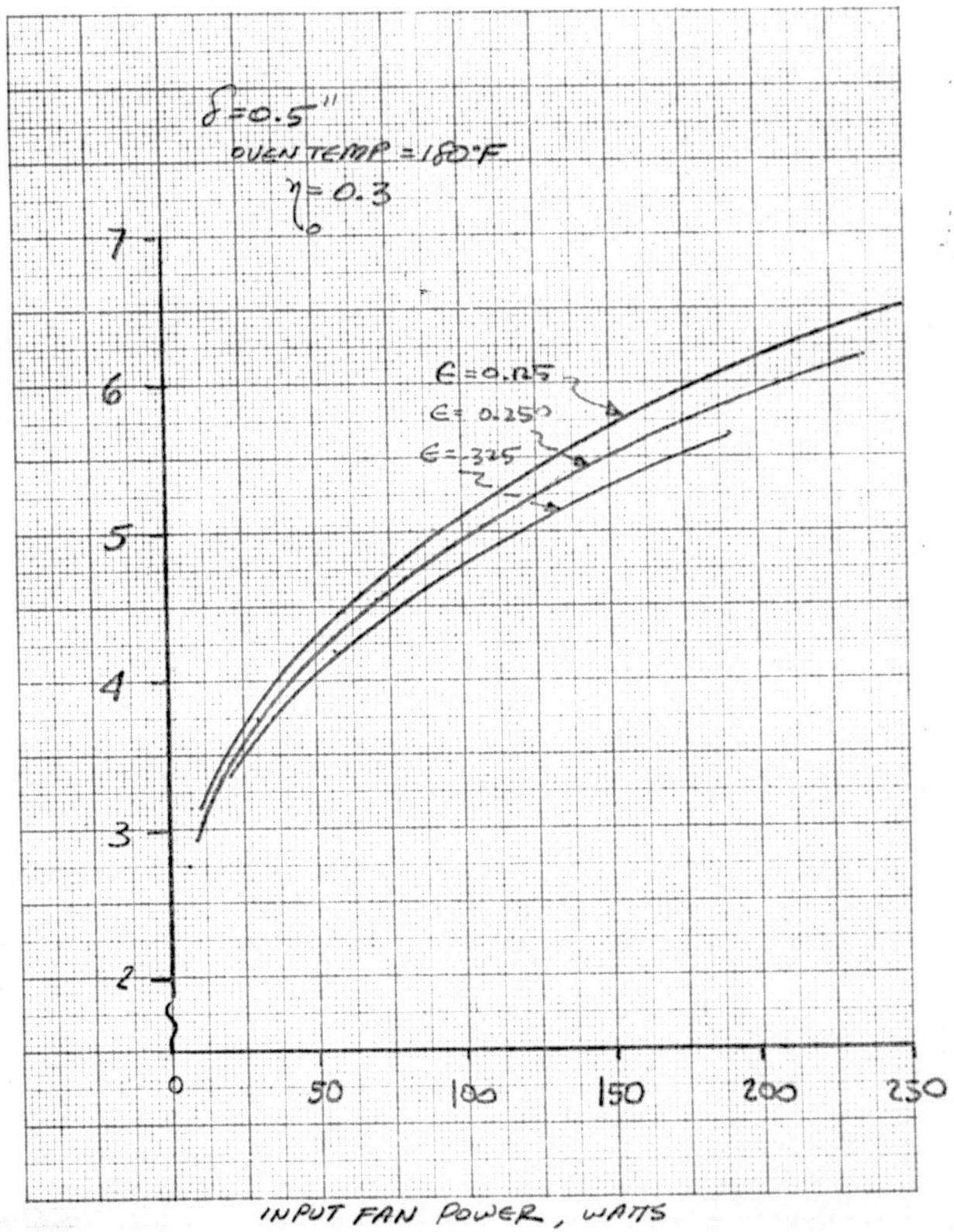
δ (in)	ϵ (in)		CFM 50	75	100	150
0.5	0.125	$\frac{h}{\sqrt{\epsilon}}$	3.5	4.52	5.54	7.59
		h	3.15	4.07	5.0	6.83
0.5	0.250	$\frac{h}{\sqrt{\epsilon}}$	3.26	4.15	5.05	6.85
		h	2.93	3.74	4.55	6.17
0.5	0.375	$\frac{h}{\sqrt{\epsilon}}$	3.07	3.87	4.67	6.28
		h	2.76	3.48	4.2	5.65



WITH FAN INPUT POWER = $0.394 \Delta P_{CFM}$, WATTS
@ $\eta_o = 0.3$ (fan efficiency)

@ $\delta = 0.5$"

ϵ	CFM	50	75	100	150
0.125"	h_{MEAN}, $\frac{BTU}{hr\,ft^2\,°F}$	3.15	4.07	5.0	6.83
	ΔP, "H_2O	0.586	1.32	2.34	5.28
	INPUT POWER, WATTS	11.5	39.0	92.2	312
0.250"	h_{MEAN}, $\frac{BTU}{hr\,ft^2\,°F}$	2.93	3.74	4.55	6.17
	ΔP, "H_2O	0.446	1.00	1.78	4.01
	INPUT POWER, WATTS	8.79	29.6	70.1	237.0
0.375	h_{MEAN}, $\frac{BTU}{hr\,ft^2\,°F}$	2.76	3.48	4.2	5.65
	ΔP, "H_2O	0.359	0.809	1.44	3.23
	Input POWER, WATTS	7.07	23.9	56.7	191.0



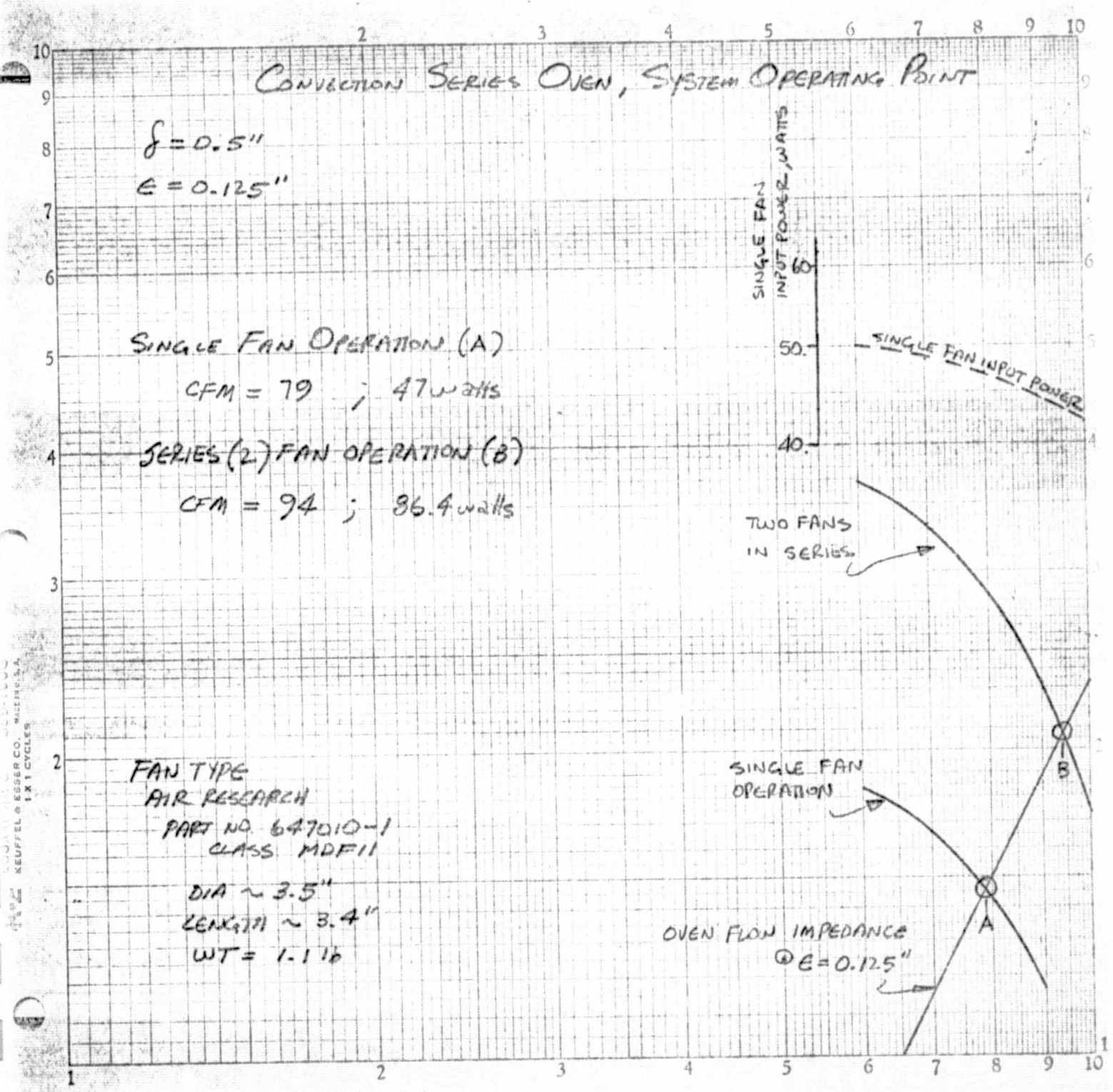
THE FOLLOWING FAN INPUT POWER LEVELS ARE REQUIRED TO ACHIEVE FOOD CAN HEAT TRANSFER COEFFICIENTS...

@ $\delta = 0.5"$ & $\epsilon = 0.125"$

h	FAN INPUT POWER *
BTU/HR-FT²-F	WATTS
4.0	36.0
4.5	61.0
5.0	93.0
5.5	132.0
6.0	180.0

* $\eta_o = 0.3$

REQUIRED FAN POWER @ $\delta = 0.5"$ IS ESSENTIALLY THE SAME LEVEL AS THAT FOR $\delta = 0.25"$; HOWEVER, THE FAN SIZE (DIAMETER) IS LARGER (& WEIGHT) SINCE A HIGHER VOLUMETRIC FLOW (CFM) IS REQUIRED. THEREFORE, THE SMALLER CLEARANCE (BOTH δ & ϵ) IS PREFERRED.



@ $\Delta P = 0.5"$ & $\epsilon = 0.125$ WITH ACTUAL FAN PERFORMANCE,

SINGLE FAN OPERATION

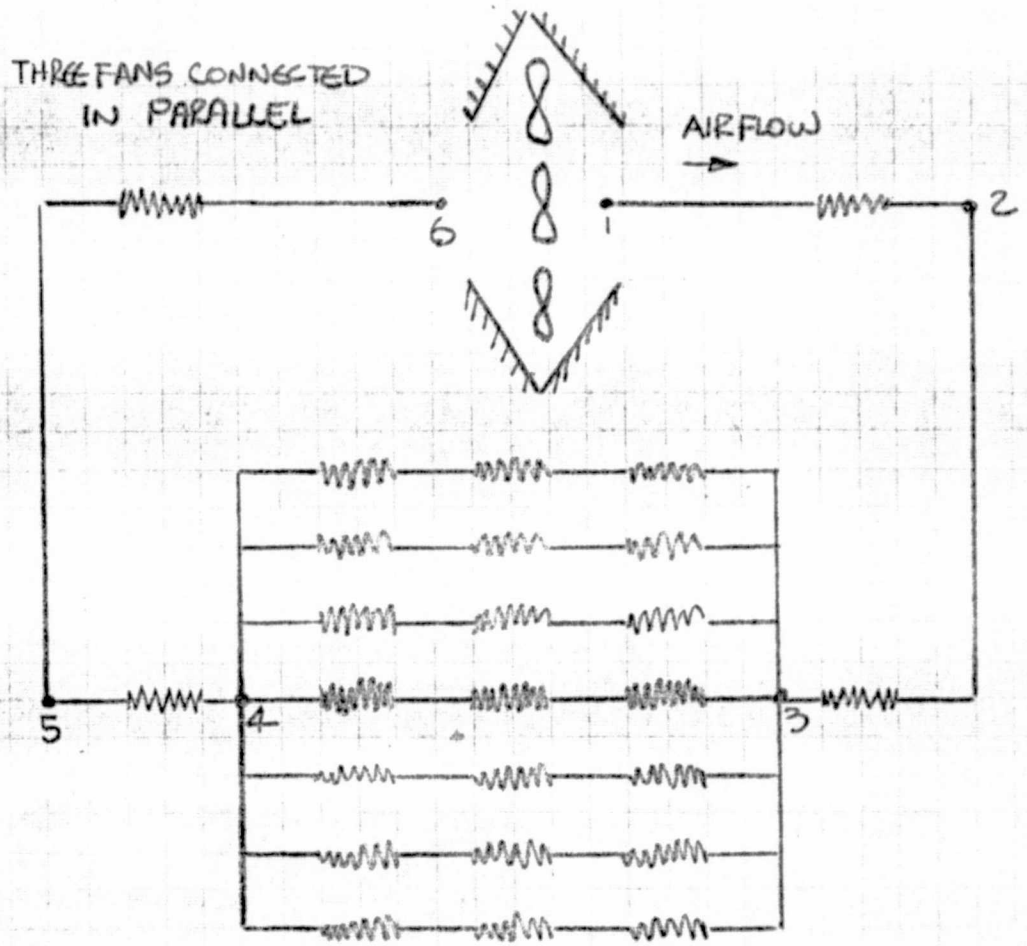
@ CFM = 79 , $h = 4.2$ BTU/hr ft² °F
(INPUT POWER, 47 watts)

SERIES (2) FAN OPERATION

@ CFM = 94 , $h = 4.75$ BTU/hr ft² °F
(INPUT POWER, 86.4 watts)

CONVECTION "PARALLEL" OVEN

EQUIVALENT AIR FLOW CIRCUIT ...



(7 TRAYS)

FLOW STATION TABULATION...

FLOW STATION	TYPE LOSS	MINIMUM FLOW AREA (in^2)	VELOCITY HEAD LOSS (MAX)	LOSS COEFFICIENT $\frac{"H_2O}{(lb/min)^2}$
12	HEADER TURN (WITH GUIDE VANES)	A_{12}	1.0	K_{12}
23	90° TURN	A_{23}	1.5	K_{23}
34	(3) SERIES CONTR/EXP	A_{34}	4.5	K_{34}
45	90° TURN	A_{45}	1.5	K_{45}
56	HEADER TURN (WITH GUIDE VANES)	A_{56}	1.0	K_{56}

THE MINIMUM AND MEAN FLOW AREAS FOR THE PARALEL OVEN ARE SET EQUAL TO THAT OF THE SERIES OVEN; THEREFORE,

① $\delta = 0.25"$ & $\epsilon = 0.125"$ $A_{MIN} = 1.33 in^2$ (PER CAN)
$A_{MEAN} = 2.39 in^2$ (PER CAN

② $\delta = 0.25"$ & $\epsilon = 0.25"$ $A_{MIN} = 1.72 in^2$ (PER CAN)
$A_{MEAN} = 2.78 in^2$ (PER CAN

PRESSURE DROP ESTIMATE FOR $\delta = 0.25"$ & $\epsilon = 0.125"$

$A_{12} = A_{56} \cong 2 \times 11.5 = 23 in^2$

$A_{23} = A_{45} = 7 \times 1.33 = 9.31 in^2$

$A_{34} = 1.33 in^2/_{TRAY}$

$$K_{12} = K_{56} = \frac{0.226 \times 1.0}{(23)^2} = 0.00043 \text{ "}H_2O/(lb/min)^2$$

$$K_{23} = K_{45} = \frac{0.226 \times 1.5}{(9.31)^2} = 0.00391 \text{ "}H_2O/(lb/min)^2$$

THRU ONE (1) FOOD TRAY ...

$$K_{34} = \frac{0.226 \times 4.5}{(1.33)^2} = 0.5749$$

WITH SEVEN (7) PARALLEL CONNECTED FOOD TRAYS ...

$$K_{34\ EFFECTIVE} = \frac{K_{34}}{(7)^2} = 0.0117$$

THEREFORE, SYSTEM FLOW IMPEDANCE ... $\sum K_{SYSTEM}$

IS GIVEN BY ,

$$K_{SYSTEM} = \sum K = K_{12} + K_{23} + K_{34} + K_{45} + K_{56}$$
$$\text{EFF}$$

$$K_{SYSTEM} = .0204 \text{ "}H_2O/(lb/min)^2$$

THE TOTAL OVEN FLOW IMPEDANCE IS GIVEN BY,

$$\Delta P = K_{SYSTEM}\, \omega^2, \text{ "}H_2O$$

$$\Delta P = \frac{.0204}{0.81}\, \omega^2 = .0252\, \omega^2, \text{ "}H_2O$$

⑤ $\delta = 0.25"$ & $\epsilon = 0.125"$

CFM	75	100	150
ω, lb/min	4.65	6.2	9.3
ΔP, "H_2O	0.545	0.969	2.18

NOTE: THE "PARALLEL" OVEN CONFIGURATION CONSIDERS THE HEATER INTEGRAL WITH OVEN WALL; AS A RESULT, NO HEATER FLOW IMPEDANCE IS USED.

@ $\delta = 0.25"$ & $\epsilon = 0.25"$

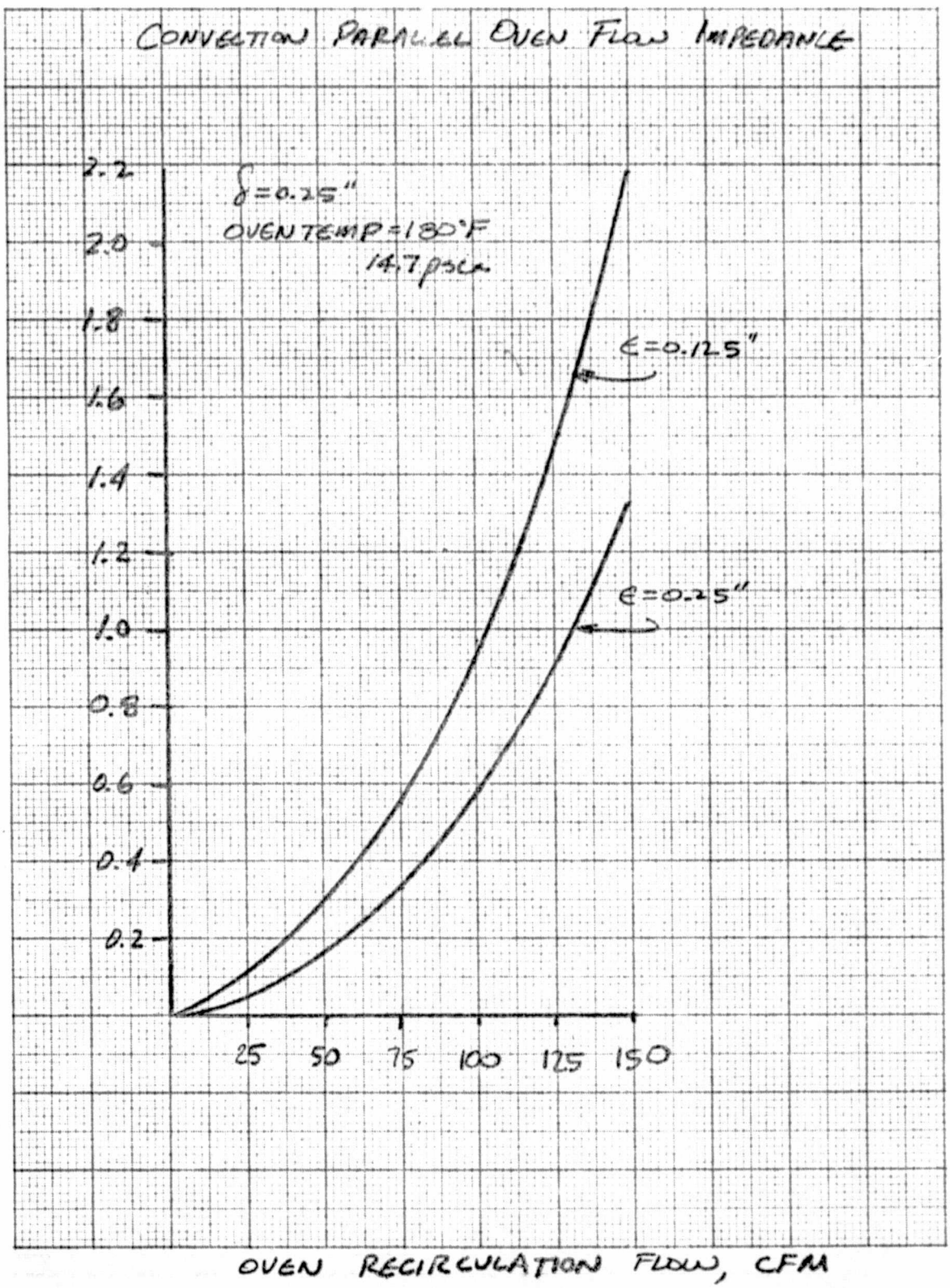
$$\sum K_{SYSTEM} = K_{12} + \left(\frac{A_{MIN}\ @\epsilon=.125"}{A_{MIN}\ @\epsilon=0.25"}\right)^2 \left(K_{23} + K_{34} + K_{45}\right)_{EFF} + K_{56}$$

$$= 0.00043 + \left(\frac{1.33}{1.72}\right)^2 (.00391 + .0117 + .00391) + .0004$$

$$\sum K_{SYSTEM} = .0125 \text{ "H}_2\text{O}/(\text{lb/min})^2$$

$$\Delta P = \frac{0.0125}{0.81} \omega^2 = 0.0154\, \omega^2 \text{, "H}_2\text{O}$$

CFM	75	100	150
ΔP, "H_2O	0.333	0.592	1.33



HEAT TRANSFER COEFFICIENT ESTIMATE ....

$$\frac{h}{\sqrt{\sigma}} = 1.46 + 0.23\sqrt{V} = 1.46 + \frac{0.562\,CFM}{(7A_{MEAN})}, \quad \frac{BTU}{hr\,ft^2\,°F}$$

① $\delta = 0.25"$ & $\epsilon = .125"$

$$\frac{h}{\sqrt{\sigma}} = 1.46 + \frac{0.552}{.7 \times 2.39} CFM = 1.46 + .033 CFM$$

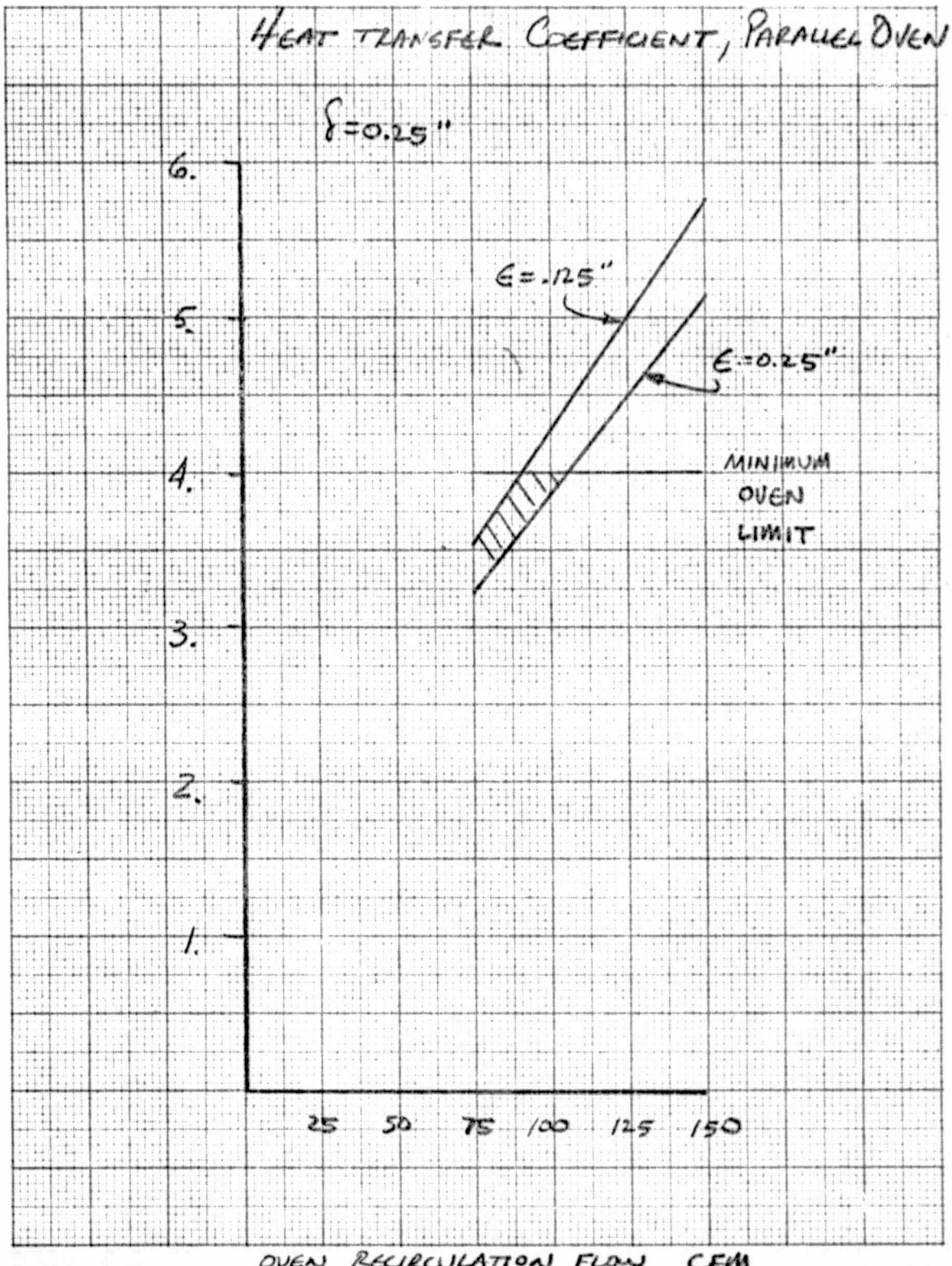
CFM	75	100	150
$h/\sqrt{\sigma}$	3.94	4.76	6.41
h $\frac{BTU}{hr\,ft^2\,°F}$	3.55	4.28	5.77

$\sqrt{\sigma} = 0.9$ @ 180°F

① $\delta = 0.25"$ & $\epsilon = 0.25"$

$$\frac{h}{\sqrt{\sigma}} = 1.46 + \frac{0.552}{7 \times 2.78} CFM = 1.46 + .0284 CFM$$

CFM	75	100	150
$h/\sqrt{\sigma}$	3.59	4.3	5.72
h $\frac{BTU}{hr\,ft^2\,°F}$	3.23	3.87	5.15



REQUIRED FAN POWER ....

FOR THE FANS CONSIDERED IN THE PARALLEL OVEN CONFIGURATION, THE OVERALL FAN EFFICIENCY IS APPROXIMATELY 0.17 (17%).

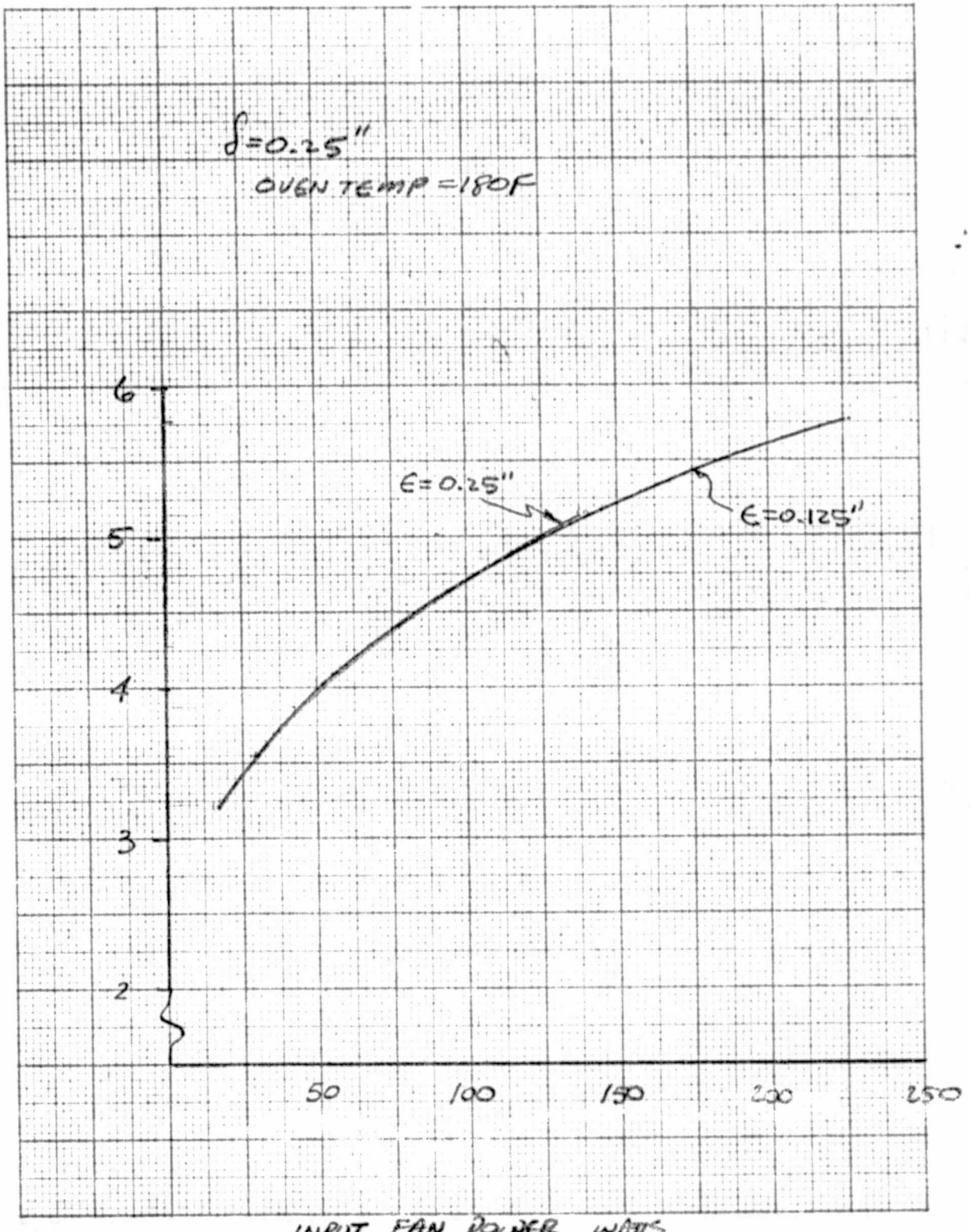
$$\text{WATTS} \cong \frac{\Delta P \, CFM}{6346 \times 0.17} 750 = 0.695 \, \Delta P \, CFM$$

$\therefore$

INPUT FAN POWER = 0.695 ΔP CFM

@ $\delta = 0.25$

ϵ	CFM	75	100	150
0.125"	h_{MEAN} BTU/HRFT²°F	3.55	4.28	5.77
	ΔP, "H_2O	0.545	0.969	2.18
	INPUT POWER, WATTS	28.4	67.3	227.3
0.25"	h_{MEAN}, BTU/HRFT²°F	3.23	3.87	5.15
	ΔP, "H_2O	0.333	0.592	1.33
	INPUT POWER, WATTS	17.4	41.1	138.7



THE FOLLOWING FAN INPUT POWER LEVELS ARE REQUIRED TO ACHIEVE FOOD CAN HEAT TRANSFER COEFFICIENTS...

@ $\delta = 0.25"$ & $\epsilon = 0.125"$

h	TOTAL FAN INPUT POWER*
BTU/hr ft²°F	WATTS
4.0	50.0
4.5	84.0
5.0	125.0
5.5	185.0

* BASED ON FAN EFFICIENCY EQUAL TO 17%

NOTE: THE OVEN DESIGN/ANALYSIS CONSIDERED FAN EFFICIENCIES BASED ON CURRENT OFF-THE-SHELF HARDWARE. AT THE SERIES OVEN REQUIRED FAN PRESSURE RATIO (AND FLOW), THE EXISTING FAN EFFICIENCIES ARE APPROXIMATELY TWICE THAT OF THE FANS USED IN THE PARALLEL OVEN. IF THE FAN EFFICIENCY USED IN THE PARALLEL OVEN WERE EQUAL TO THAT OF THE SERIES OVEN, THE INPUT POWER

LEVELS WOULD BE 43 PERCENT BELOW THE VALUES SHOWN ABOVE. A FAN EFFICIENCY HIGHER THAN 17% IS ACHIEVABLE FOR THE PARALLEL OVEN CONFIGURATION.

CONVECTION PARALLEL OVEN, SYSTEM OPERATING POINT

TWO PARALLEL FAN OPERATION

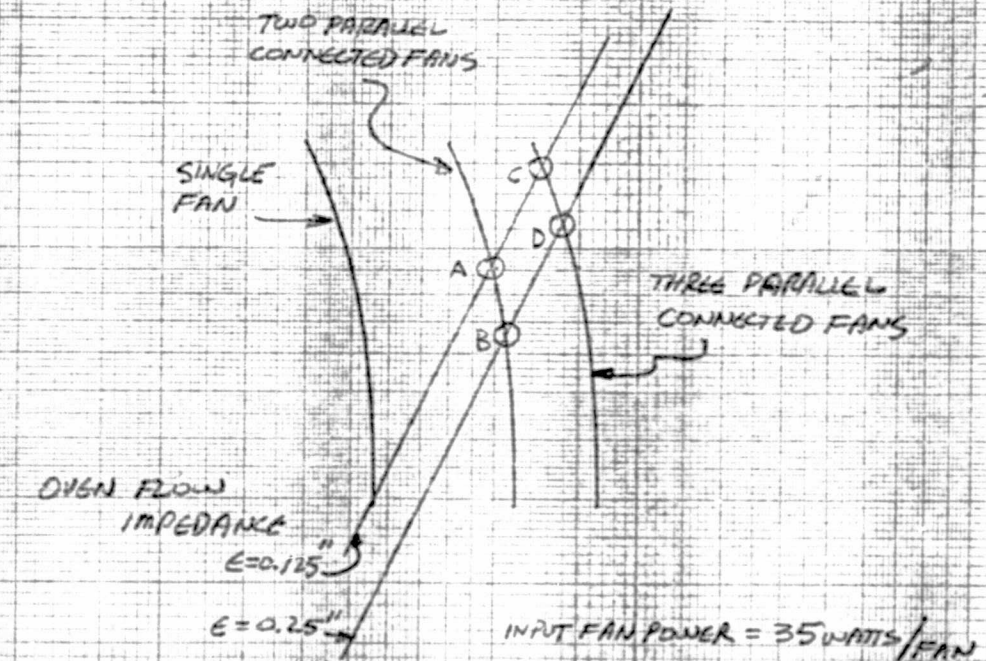
@ $\epsilon = 0.125''$, $CFM_A = 98$; 70 WATTS

$\epsilon = 0.25''$, $CFM_B = 105$; 70 WATTS

THREE PARALLEL FAN OPERATION

@ $\epsilon = 0.125''$, $CFM_C = 125$; 105 WATTS

$\epsilon = 0.25''$, $CFM_D = 139$; 105 WATTS



FAN TYPE

ROTRON
VANEAXIAL FAN
AXIMAX 2

DIA ~ 2"

LENGTH ~ 1.5"

WT ~ 0.28 lbs

INPUT FAN POWER = 35 WATTS/FAN

@ $\delta = 0.25"$ & $\epsilon = 0.125"$ (BASED ON ACTUAL FAN PERFORMANCE)

TWO PARALLEL FAN OPERATION

@ CFM = 98 , $h = 4.2$ BTU/hr ft^2 °F

INPUT POWER = 70 WATTS

THREE PARALLEL FAN OPERATION

@ CFM = 125 , $h = 5.0$ BTU/hr ft^2 °F

INPUT POWER = 105 WATTS

@ $\delta = 0.25"$ & $\epsilon = 0.25"$

TWO PARALLEL FAN OPERATION

@ CFM = 105 , $h = 3.9$ BTU/hr ft^2 °F

INPUT POWER = 70 WATTS

THREE PARALLEL FAN OPERATION

@ CFM = 139 , $h = 4.85$ BTU/hr ft^2 °F

INPUT POWER = 105 WATTS

FOOD CAN CLEARANCE & OVEN CONFIGURATION	NO. OF FANS OPERATING	TOTAL OVEN RECIRCULATION FLOW CFM	MEAN HEAT TRANSFER COEFFICIENT BTU/HR FT^2 °F	TOTAL FAN(S) INPUT POWER WATTS*
SERIES δ=0.25" ϵ=0.125"	1	63	4.6	56.8
	2	74	5.15	108.0
PARALLEL δ=0.25" ϵ=0.125"	2	98	4.2	70.0
	3	125	5.0	105.0
SERIES δ=0.25" ϵ=0.25"	1	71	4.5	56.0
	2	78	4.8	103.0
PARALLEL δ=0.25" ϵ=0.25"	2	105	3.9	70.0
	3	139	4.85	105.0

COMMENTS

1. OVEN TEMP=180°F @14.7 psia
2. FOR SERIES OVEN; SINGLE FAN WEIGHT, 0.52 #
3. FOR PARALLEL OVEN; SINGLE FAN WEIGHT, 0.28 #

* BASED ON ACTUAL FAN PERFORMANCE

PREPARED
CHECKED
REVISED SUMMARY

AIRCHILD
REPUBLIC COMPANY
FARMINGDALE, L.I., NEW YORK 11735

A148V0009

REPORT NO.
MODEL

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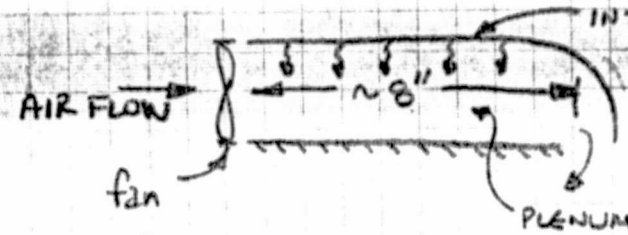
FEASABILITY STUDY, PARALLEL OVEN WITH "INTEGRAL" WALL HEATER.

PLENUM DUCT CROSS SECTION = $2 \times 11.7 = 23.4 \text{ in}^2 = 0.163 \text{ ft}^2$



WITH (3) THREE FANS OPERATING, RESULTING AIR FLOW, 125 ft/min (ε = 0.125")

THE FULLY DEVELOPED FLOW, HEAT TRANSFER COEFFICIENT CAN ALSO BE EXPRESSED AS ...

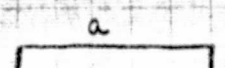
$$\frac{h}{\sqrt{\sigma}} = 1.46 + 0.23 \frac{CFM \times 144}{60 A_{PLENUM}}$$

(A_{PLENUM} in in^2)

$$\frac{h}{\sqrt{\sigma}} = 1.46 + \frac{0.23 \times 125 \times 144}{60 \times 23.4} = 4.41 \frac{BTU}{hr\,ft^2 \cdot °F}$$

@ 180°F, 14.7 psia $\quad h = 4.41 \times 0.9 = 3.97 \text{ BTU/hr ft}^2\text{°F}$ (FULLY DEVELOPED VALUE)

DUCT HYDRAULIC DIA, D_{HYD}



$$D_{HYD} = \frac{4ab}{2(a+b)} = \frac{2(2 \times 11.7)}{2+11.7} = 3.42"$$

REYNOLDS No, $R_e = \frac{\omega}{A}\frac{D_{HYD}}{\mu} \cong \frac{125\ ft^3/min \times 0.062 \times 60}{0.1625\ ft^2} \times \frac{3.42/12\ ft}{0.05\ lb/ft\ hr}$

$R_e = 16{,}310$ TURBULENT FLOW

FOR SHORT TUBES (I.E., $\frac{L}{D_H} < 60$ .....

... FOR THIS DUCT, $\frac{L}{D_H} \cong \frac{8.0}{3.42} = 2.34$

$\frac{h_{PLENUM}}{h_{FULLY\ DEVELOPED}} \cong 1 + 6/L/D_H = 1 + \frac{6}{2.34} = 3.56$

REF: KREITH, PRINC. of HEAT TRANSFR

$\therefore h_{PLENUM} \sim 3.56\, h_{FULLY\ DEVELOPED}$

$h_{PLENUM} = 3.56 \times 3.97 = 14.1\ \frac{BTU}{hr\,ft^2\,°F}$ TOO HIGH

OTHER HEAT TRANSFER COEFFICIENT CORRELATIONS RESULT IN ESTIMATES FOR FULLY DEVELOPED HEAT TRANSFER COEFFICIENT COEFFICIENTS AS LOW AS $2.85\ \frac{BTU}{hr\,ft^2\,°F}$

THEREFORE, $h_{PLENUM} = 3.56 \times 2.85 = 10.1\ BTU/hr\,ft^2\,°F.$

FOR ESTIMATING HEATER SIZE, USE A CONSERVATIVE VALUE OF $h_{PLENUM} = 5.0\ BTU/hr\,ft^2\,°F.$

THE REQUIRED INTEGRAL WALL HEATER SURFACE AREA IS SIMPLY GIVEN AS ...

$$A_{HEATER} = \frac{q \times 3.41}{h_{PLENUM}(T_{SURFACE} - 180)}, \text{ ft}^2$$

② $h_{PLENUM} \sim 5.0$ BTU/HR FT^2 °F

$q \sim$ WATTS

$$A_{HEATER} = \frac{0.682\, q}{T_{SURF} - 180}$$

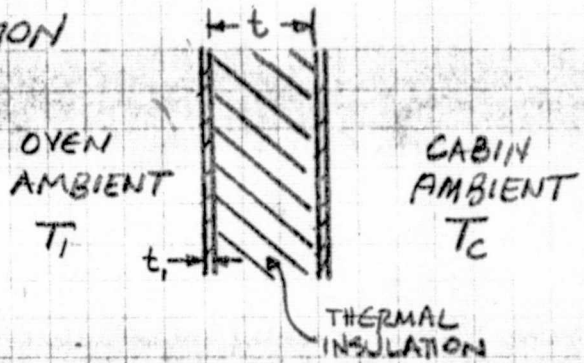
③ $T_{SURF} = 400$ °F , $A_{HEATER} = .0031\, q$

q, WATTS	300	400	500
A_{HEATER}, ft^2	0.93	1.24	1.55
in^2	133.9	178.6	223.2

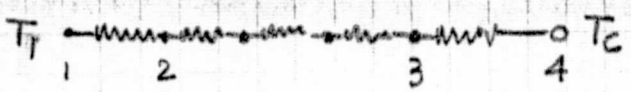
OVEN HEAT LEAK DURING STEADY STATE OPERATION

A-SERIES OVEN CONFIGURATION ...

DOOR CROSS SECTION



THERMAL CIRCUIT



PROPERTIES SIMILAR TO JOHN MANSVILLE GLASS FIBRE INSULATION ...

THERMAL CONDUCTIVITY, $K = 0.25 \frac{BTU \cdot in}{hr\,ft^2\,^\circ F}$

DENSITY, $\rho = 0.6\ lb/ft^3$

NOMENCLATURE ....

q_b/A = heat flux, BTU/hr ft²

T_1 = OVEN TEMP

T_2 = OVEN INSIDE WALL TEMP

T_3 = OVEN OUTSIDE WALL TEMP

T_4 = CABIN AMBIENT

t_1 = ALUMINUM WALL THICKNESS

t = INSULATION THICKNESS

K_1 = ALUMINUM THERMAL CONDUCTIVITY

K = INSULATION THERMAL CONDUCTIVITY

h_{12} = OVEN AMBIENT HEAT TRANSFER COEFFICIENT

h_{34} = HEAT TRANSFER COEFFICIENT AT EXTERNAL OVEN WALL

ENERGY BALANCE ON OVEN DOOR...

$$q/A = U_o(T_1 - T_4) = h_{34}(T_3 - T_4)$$

where $$U_o = \frac{1}{\frac{1}{h_{12}} + \frac{t_1}{k_1} + \frac{t}{k} + \frac{1}{h_{34}}}$$

since $\frac{t}{k} >> \frac{t_1}{k_1}$

$$U_o = \frac{1}{\frac{1}{h_{12}} + \frac{t}{k} + \frac{1}{h_{34}}}$$

$$\therefore \quad \frac{T_1 - T_4}{\frac{1}{h_{12}} + \frac{t}{k} + \frac{1}{h_{34}}} = h_{34}(T_3 - T_4)$$

RE-ARRANGED,

$$\boxed{t = \frac{k}{h_{34}} \left\{ \frac{T_1 - T_4}{T_3 - T_4} - 1 - \frac{h_{34}}{h_{12}} \right\}}$$

MINIMUM OVEN INSULATION THICKNESS FOR MEETING "TOUCH" TEMPERATURE REQUIREMENT....

$h_{34} = 4.0 \text{ & } 6.0 \quad BTU/hr\,ft^2\,°F$ (TWO VALUES ARE CONSIDERED)

$K = 0.25 \dfrac{BTU \cdot in}{hr\,ft^2 \cdot °F}$

$T_1 - T_4 = 180 - 70 = 110°F$

$T_3 - T_4 = 105 - 70 = 35°F$

$h_{12} = h_{CONVECTION} + h_{RADIATION}$

$h_{CONVECTION} = 1.46 + 0.23V$,

WITH CABIN AIR VELOCITY, $V \sim 1$ ft/sec, $h_{CONVECTION} = 1.68$

THE EXPRESSION FOR $h_{RADIATION}$ IS OBTAINED AS FOLLOWS.....

$$T_3^4 - T_4^4 = (T_3 + \Delta T)^4 - T_4^4$$

where $\Delta T = T_3 - T_4$

$$T_3^4 - T_4^4 = 4T_4^3 \Delta T \left[1 + 1.5\frac{\Delta T}{T_0} + \left(\frac{\Delta T}{T_0}\right)^2 + 0.25\left(\frac{\Delta T}{T}\right)^3\right.$$

$$\therefore \quad q/A = \sigma\epsilon\left(T_3^4 - T_4^4\right) \cong \sigma\epsilon\, 4T_4^3 \Delta T$$

for the range of ΔT's considered, this approximation results in an error less than 10%.

$$\therefore \sigma \epsilon 4 T_4^3 \Delta T \equiv h_{RADIATION} \Delta T$$

$$h_{RADIATION} = 4 \sigma \epsilon T_4^3$$

with

$\epsilon = 0.85$

$T_4 = 530°R$ (70F)

$\sigma = 0.173 \times 10^{-8}$

$h_{RAD} = 0.88$ BTU/HR FT^2·F

so that, $h_{12} = 1.68 + 0.88 = 2.56 \frac{BTU}{hr\,ft^2 \cdot F}$

Finally,

① $h_{34} = 4.0 \frac{BTU}{hr\,ft^2 \cdot F}$, $t = 0.147"$ MIN

② $h_{34} = 6.0 \frac{BTU}{hr\,ft^2 \cdot F}$, $t = 0.168"$ MIN

Insulation thicknesses larger than the above minimums are used to limit oven heat leak.

FOR SERIES OVEN, THE OVEN DOOR SURFACE AREA, A_{DOOR} IS GIVEN BY

$$A_{DOOR} \simeq (20+2t)(13.2+2t)$$
$$= 262.4 + 66.2t + 4t^2 \text{ , in}^2$$

t	0.25"	0.5"	0.75"
A_{DOOR}	279.2 in^2	296.5 in^2	314.3 in^2

THE OTHER FIVE (5) OVEN SIDES HAVE A TOTAL SURFACE AREA, A_{RAD}, GIVEN BY

$$A_{RAD} = 601.5 + 239.6t + 20t^2 \text{ , in}^2$$

t	0.25"	0.5"	0.75"
A_{RAD}	662.7 in^2	726.3 in^2	792.5 in^2

DOOR LEAKAGE ... $t = 0.5"$

FROM ENERGY BALANCE,

$$U_{13}(T_1 - T_3) = h_{34}(T_3 - T_4)$$

SOLVING FOR T_3,

$$T_3 = \frac{U_{13}}{U_{13}+h_{34}} T_1 + \frac{h_{34}}{U_{13}+h_{34}} T_4$$

WITH $U_{13} = \dfrac{1}{\frac{1}{h_{12}} + \frac{t}{K}}$

h_{12}	4.0	6.0
U_{13}	0.444	0.462
T_3	86.25F	86.82F

THEREFORE HEAT LEAK THRU DOOR,

$$q_{\substack{LEAK \\ DOOR}} = h_{34} A_{DOOR} (T_3 - T_4) / 3.41 \text{ , WATTS}$$

h_{12} BTU/HR FT² F	4.0	6.0
$q_{\substack{DOOR \\ LEAK}}$ (WATTS)	25.12	26.0

HEAT LEAK THRU FIVE REMAINING OVEN SIDES (CONSIDERED TO RADIATE TO AN EFFECTIVE HEAT SINK AT 530°R)

FROM ENERGY BALANCE,

$$U_{13} A_{RAD} (T_1 - T_3) = 4\sigma\epsilon A_{RAD} T_{SINK}^3 (T_3 - T_{SINK})$$

REARRANGED

$$T_3 = \frac{U_{13}}{U_{13} + 4\sigma\epsilon T_{SINK}^3} T_1 + \frac{4\sigma\epsilon T_{SINK}^3}{U_{13} + 4\sigma\epsilon T_{SINK}^3} T_{SINK}$$

h_{12}	4.0	6.0
T_3	106.88F	107.84F

THE RADIATION HEAT LEAK FROM ALL FIVE SURFACES,

$$q_{RAD} = 4\sigma\epsilon T_{SINK}^3 A_{RAD} (T_3 - T_{SINK}) / 3.41 \text{ , WATTS}$$

h_{12}	4.0	6.0
q_{RAD} (WATTS)	48.0	49.25

THEREFORE, TOTAL OVEN HEAT LEAK @ $t = 0.5"$

h_{12}	4.0	6.0
TOTAL OVEN HEAT LEAK (WATTS)	73.12	75.22

DOOR LEAKAGE .... $t = 0.75"$

@ $h_{12} = 4.0$, $U_{13} = 0.3077$

$h_{12} = 6.0$, $U_{13} = 0.3158$

USING SAME EQUATIONS AS BEFORE,

h_{12}	4.0	6.0
T_3	81.8F	82.07
q_{DOOR} (WATTS)	18.24	18.66

HEAT LEAK THRU REMAINING 5 SIDES,

h_{12}	4.0	6.0
T_3	98.5F	99.6F
q_{RAD} (WATTS)	37.1	38.53

THEREFORE, TOTAL OVEN HEAT LEAK @ $t=0.75"$

h_{12}	4.0	6.0
TOTAL OVEN HEAT LEAK (WATTS)	55.34	57.19

DOOR LEAKAGE ... $t = 0.25$

@ $h_{12} = 4.0$, $U_{13} = 0.8$

$h_{12} = 6.0$, $U_{13} = 0.857$

USING SAME EQUATIONS AS BEFORE,

h_{12}	4.0	6.0
T_3	96.2F	97.62F
q_{DOOR} (WATTS)	40.5	42.69

THE RADIATION LEAKAGE THRU REMAINING 5 SIDES,

h_{12}	4.0	6.0
T_3	122.35F	124.2F
q_{RAD} (WATTS)	68.14	70.55

THEREFORE, TOTAL OVEN HEAT LEAK @ $t = 0.25$"

h_{12}	4.0	6.0
TOTAL OVEN HEAT LEAK (WATTS)	108.64	113.24

HEAT LEAK SUMMARY FOR "SERIES" OVEN @ $h_{12} = 4.0$ BTU/HR FT^2·F

INSULATION THICKNESS (INCHES)	TOTAL OVEN HEAT LEAK (WATTS)
0.25	108.6
0.50	73.1
0.75	55.3

B - PARALLEL OVEN CONFIGURATION

FOR PARALLEL OVEN, THE OVEN DOOR SURFACE AREA, A_{DOOR}, IS GIVEN BY,

$$A_{DOOR} = (14.31 + 2t)(11.5 + 2t)$$
$$= 164.57 + 51.62t + 4t^2 \text{ , in}^2$$

t	0.25	0.5	0.75
A_{DOOR} in^2	177.72	191.38	205.54

THE OTHER FIVE OVEN SIDES HAVE A TOTAL SURFACE AREA, A_{RAD}, GIVEN BY

$$A_{RAD} = 545.27 + 213.86t + 20t^2 \text{ , } in^2$$

t	0.25	0.5	0.75
A_{RAD} (in^2)	600.	657.2	716.92

LEAKAGE @ $t=0.5''$ & $h_{12} = 4.0 \frac{BTU}{hr\,ft^2\,°F}$

$$q_{DOOR} = h_{34} A_{DOOR} (T_3 - T_4) / 3.41 = 16.2 \text{ watts}$$

T_3 SAME AS BEFORE @ $t=0.5''$
$h_{12} = 4.0$

$$q_{RAD} = 4\sigma\epsilon T_{SINK}^3 (T_3 - T_{SINK}) / 3.41 = 43.44 \text{ watts}$$

$$q_{TOTAL} = q_{DOOR} + q_{RAD} = 59.64 \text{ watts}$$

LEAKAGE @ $t=0.75"$ & $h_{12} = 4.0$ BTU/HR FT² °F

$$q_{DOOR} = 2.56 \times \frac{205.54}{144} \frac{(11.8)}{3.41} = 12.64 \text{ watts}$$

$$q_{RAD} = 0.88 \times \frac{716.92}{144} \frac{(28.5)}{3.41} = 36.62 \text{ watts}$$

$$q_{TOTAL} = 49.26 \text{ watts}$$

LEAKAGE @ $t=0.25"$ & $h_{12} = 4.0$ BTU/HR FT² °F

$$q_{DOOR} = 2.56 \times \frac{177.72}{144} (26.2)/3.41 = 24.28 \text{ watts}$$

$$q_{RAD} = 0.88 \times \frac{600}{144} (52.35)/3.41 = 56.29 \text{ watts}$$

$$q_{TOTAL} = 80.57 \text{ watts}$$

OVEN HEAT LEAK SUMMARY @ $h_2 = 4.0$ BTU/HR-FT^2-F

INSULATION THICKNESS (IN)	SERIES OVEN TOTAL HEAT LEAK (WATTS)	PARALLEL OVEN TOTAL HEAT LEAK (WATTS)
0.25	108.6	80.5
0.50	73.1	59.6
0.75	55.3	49.3

HEAT LEAKAGE, PARALLEL OVEN CONFIGURATION .....

FINAL CONFIGURATION WITH DOOR AS SHOWN IN FIGURE 3-10

@ $t = 0.5"$

$A_{DOOR} = 8.12 \times 12.75 = 103.53\ in^2$

$A_{RAD} = 103.53 + 14.82 \times 8.12 \times 2 + 14.82 \times 12.75 \times 2 = 722.12\ in^2$

@ $h_{12} = 4.0\ BTU/HR\,FT^2\,^\circ F$, $\overline{T_3} = 86.25 F$

$$q = h_{34} A_{DOOR} (T_3 - T_4)/3.41$$

$$q_{\substack{DOOR \\ LEAK}} = 2.56 \times \frac{103.53}{144} \frac{(16.25)}{3.41} = 8.77\ watts$$

HEAT LEAK THRU REMAINING OVEN SIDES ...

WITH $T_3 = 106.88^\circ F$ & $h_{RAD} = 0.88 \frac{BTU}{hr\,ft^2\,^\circ F}$

$$q_{RAD} = 0.88 \times \frac{722.12}{144} \frac{(36.88)}{3.41} = 47.73\ watts$$

∴ TOTAL OVEN LEAK @ $t = 0.5"$

$$q_{TOTAL} = 56.5\ watts$$

HEAT LEAKAGE, CONDUCTION OVEN, CONFIGURATION AS SHOWN IN FIGURE 3-23

OVEN INNER WALL TEMPERATURE = 150 F

OVEN DOOR FACE AREA = 93.8 in^2

INSULATION THICKNESS = 0.5"

ENERGY BALANCE ON WALL,

$$\frac{1\ (150 - T_{SURF})}{\left(\frac{t}{k}\right)_{LEXAN} + \left(\frac{t}{k}\right)_{INSUL} + \left(\frac{t}{k}\right)_{ALUM}} \approx \left(\frac{K}{t}\right)_{INSUL} (150 - T_{SURF}) = h_{SURFACE}\,(T_{SURF} - 70)$$

with $\left(\frac{K}{t}\right)_{INSUL} = \frac{0.25}{0.50} = 0.5 \frac{BTU}{hr\,ft^2\,^\circ F}$

$$0.5 \times 150 - 0.5\,T_{SURF} = 2.56\,T_S - 2.56 \times 70$$

$$T_{SURF} = \frac{254.2}{3.06} = 83.07\,F$$

WITH $A_{DOOR} = \frac{6.7 \times 14.0}{144} = 0.651\,ft^2$

$$q_{\substack{DOOR \\ LEAK}} = h_{SURF}\,A_{DOOR}\,(T_{SURF} - 70)/3.41$$

$$q_{\substack{DOOR \\ LEAK}} = 2.56 \times 0.651 \times 13.07/3.41 = 6.39 \text{ WATTS}$$

ON REMAINING FIVE SIDES ... SKIN TEMP, T_{SKIN} ...

$$\left(\frac{K}{t}\right)_{INSUL} (150 - T_{SKIN}) = h_{RAD} (T_{SKIN} - 70)$$

AS BEFORE, $h_{RAD} = 0.88$ BTU/HR FT^2 °F

$$\therefore T_{SKIN} = 99F$$

$$q_{RAD} = 0.88 \times \frac{723.08}{144} (99-70) / 3.41$$

$$q_{RAD} = 37.58 \text{ WATTS}$$

NOTE: $A_{RAD} = 93.8 + 15.2 \times 14 \times 2 + 15.2 \times 6.7 \times 2 = 723.08$ in^2

THEREFORE TOTAL OVEN LEAKAGE ...

$$6.39 + 37.58 \cong \underline{44 \text{ WATTS}}$$

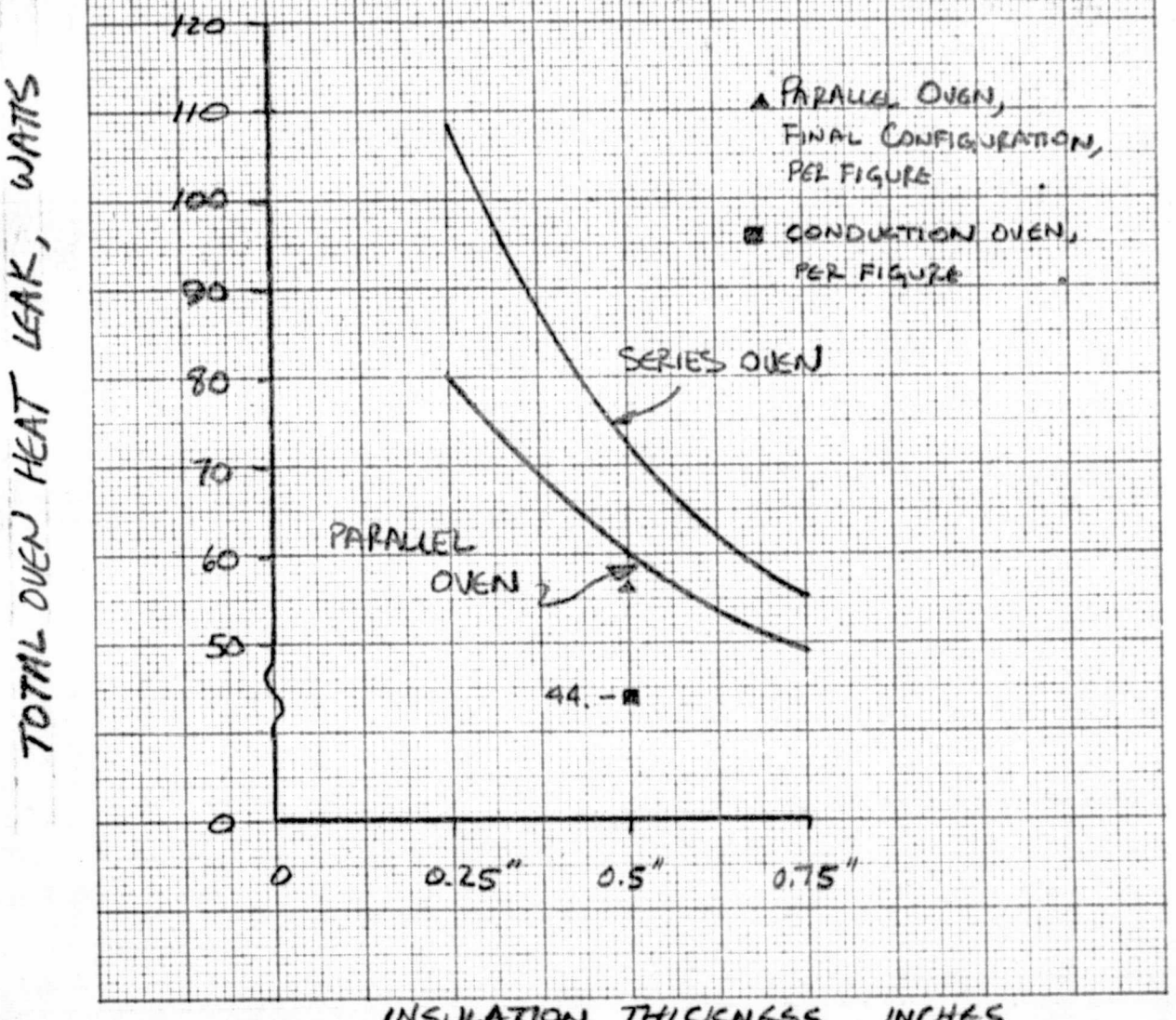
OVEN HEAT LEAK VS INSULATION THICKNESS

(STEADY STATE OPERATION)

OVEN TEMP = 180F

INTERNAL HEAT TRANSFER COEFFICIENT = 4.0 $\frac{BTU}{hr\,ft^2\,°F}$

OVEN EXTERNAL SURFACE ϵ = 0.85 (EMISSIVITY)



APPENDIX B

Thermal Analysis

THERMAL ANALYSIS

FOOD HEATING IS ANALYSED USING THE METHOD OF FINITE DIFFERENCES AS DEVELOPED BY DUSINBERRE.(1). THE ANALYSIS IS BASED ON A TWO DIMENSIONAL $r-z$ SYSTEM, WITH THE CYLINDRICAL FOOD MASS CONSIDERED AXISYMMETRIC. THE $r-z$ SECTION IS SUBDIVIDED BY A GRID OF RADIAL INCREMENTS, Δr, AND AXIAL INCREMENTS, Δz. FOR SIMPLICITY THESE DIVISIONS ARE TAKEN AS UNIFORM AND EQUAL AND ARE LABELED ΔX. OTHER SYMBOL USED ARE:

k = CONDUCTIVITY, BTU/HR-FT-°F

h = SURFACE COEFFICIENT OF HEAT TRANSFER, BTU/HR-FT^2-°F

c = SPECIFIC HEAT, BTU/#-°F

ρ = DENSITY, #/FT^3

$\Delta\tau$ = TIME INCREMENTS, HR

V = VOLUME, FT^3

T = TEMPERATURE OF CELL, CURRENT, °F

T' = TEMPERATURE OF CELL AFTER TIME INCREMENT $\Delta\tau$, °F

G. M. DUSINBERRE, "HEAT-TRANSFER CALCULATIONS BY FINITE DIFFERENCES", INTERNATIONAL TEXTBOOK CO., 1961

i = SUBSCRIPT, INDEX OF AXIAL SUBDIVISION

j = SUBSCRIPT, INDEX OF RADIAL SUBDIVISION

I = VALUE OF INDEX i USED IN CALCULATION

J = VALUE OF INDEX j USED IN CALCULATION

A = AREA OF ONE OF THE FOUR FACES OF CELL, FT^2

II = INDEX VALUE OF LAST AXIAL SUBDIVISION

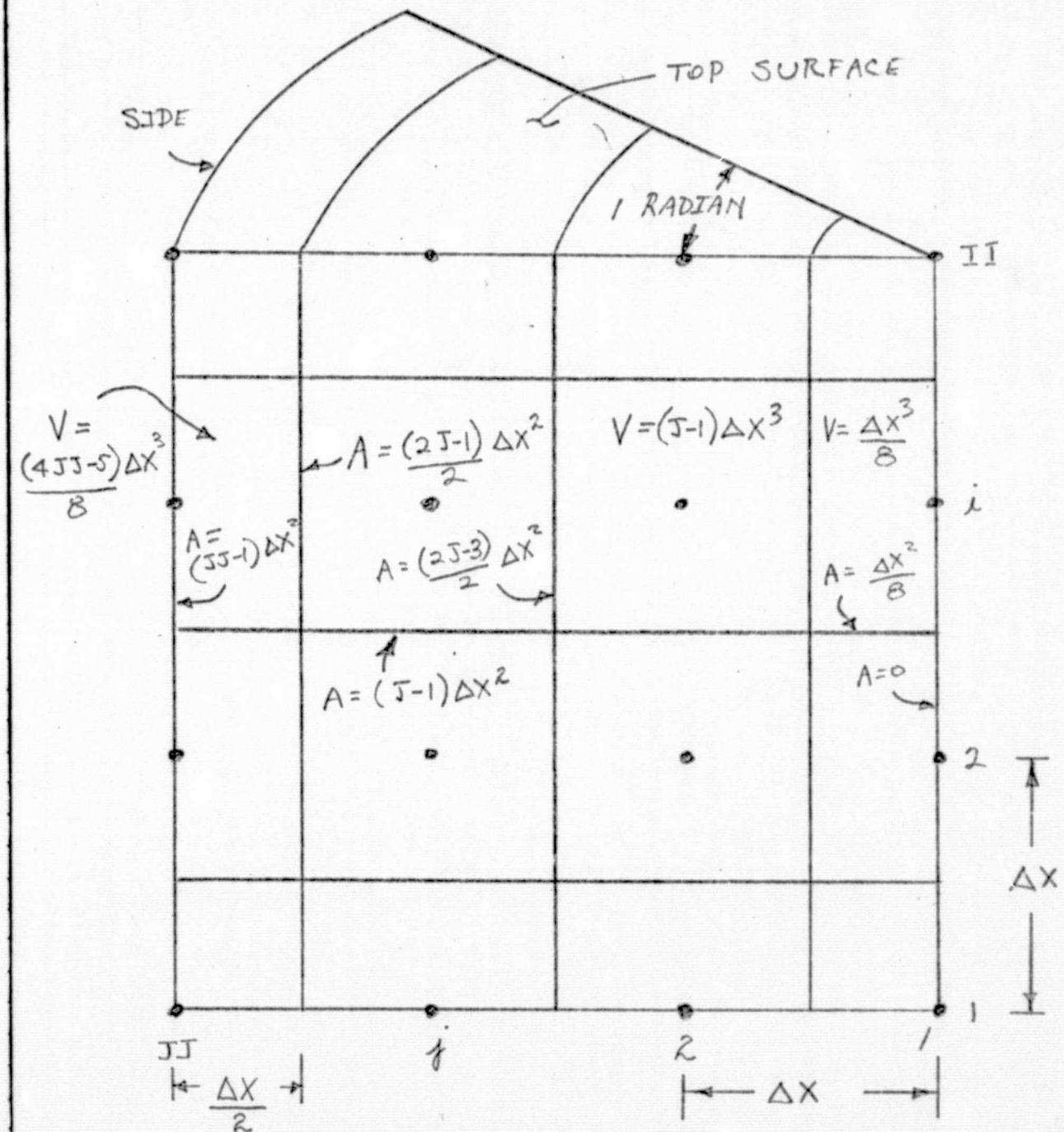
JJ = INDEX VALUE OF LAST RADIAL SUBDIVISION

q = HEAT FLOW, BTU/HR

T_g = AIR TEMP., CONVECTION OVEN, ^oF

T_f = FIXED BOUNDARY TEMP., CONDUCTION OVEN, ^oF

THE r-z FIELD IS SUBDIVIDED INTO CELLS AS SHOWN BELOW.



• = TEMP. NODE

THE TEMPERATURE CHARACTERISTIC OF THE CELL IS LOCATED AT THE CENTER OF INTERIOR CELLS, AND CENTERED AT THE SURFACE OF BOUNDARY CELLS. IN GENERAL NINE DISTINCT CELL TYPES MUST BE CONSIDERED; INTERIOR CELLS, FOUR SIDE CELLS, AND THE FOUR CORNERS. THE ENERGY BALANCE FOR THE CELL i,j IS RELATED TO THE HEAT FLOW ACROSS ITS FOUR FACES AS FOLLOWS:

$$\left(T'_{i,j} - T_{i,j}\right) \frac{c\rho}{\Delta\tau} V_{i,j} = \sum q_{\rightarrow i,j}$$

WHERE $q_{\rightarrow i,j}$ IS THE HEAT FLOW FROM ADJACENT CELLS BY CONDUCTION:

$$q = \frac{k A}{\Delta x} \Delta T \quad ,$$

OR HEAT FLOW AT THE BOUNDARY BY CONVECTION

$$q = h A \Delta T \quad .$$

CONVECTION OVEN

INTERIOR CELLS, $I = 2$ TO $II-1$, $J = 2$ TO $JJ-1$

ENERGY BALANCE FOR CELL i,j :

SINCE THE FOOD CONDUCTIVITY FOR A GIVEN CELL DEPENDS ON ITS STATE (BUT k IS NOT OTHERWISE CONSIDERED AS A FUNCTION OF T), THE GENERAL VALUE OF k FOR CONDUCTION BETWEEN TWO CELLS i,j AND $i,j-1$ SAY, IS :

$$k^* = k_{i,j}\, k_{i,j-1} \Big/ 0.5(k_{i,j} + k_{i,j-1}) .$$

$$\left(T'_{i,j} - T_{i,j}\right)\frac{c\rho}{\Delta\tau}(J-1)\Delta X^3 = \left(T_{i,j-1} - T_{i,j}\right)\frac{k^*}{\Delta X}\,\frac{(2J-3)}{2}\,\Delta X^2$$

$$+\left(T_{i-1,j} - T_{i,j}\right)\frac{k^*}{\Delta X}\,(J-1)\,\Delta X^2$$

$$+\left(T_{i+1,j} - T_{i,j}\right)\frac{k^*}{\Delta X}\,(J-1)\,\Delta X^2$$

$$+\left(T_{i,j+1} - T_{i,j}\right)\frac{k^*}{\Delta X}\,\frac{(2J-1)}{2}\,\Delta X^2$$

SOLUTION FOR $T'_{i,j}$:

DEFINE A GENERAL TERM $\frac{1}{M}$ AS

$$\frac{1}{M} = \frac{k^*\,\Delta\tau}{c\rho\,\Delta x^2} .$$

THE TERM $\frac{1}{M}$ DEPENDS ON THE STATE OF THE TWO CELL CONSIDERED IN THE HEAT EXCHANGE, SINCE THE VALUE OF k^* AND c DEPEND ON THE STATE OF THE CELLS. NOW THE TEMPERATURE OF CELL i,j AFTER THE INTERVAL $\Delta\tau$ IS:

$$T'_{i,j} = T_{i,j-1}\frac{1}{M_1}\cdot\frac{(2J-3)}{2(J-1)} + T_{i+1,j}\frac{1}{M_2}$$

$$+ T_{i,j+1}\frac{1}{M_3}\frac{(2J-1)}{2(J-1)} + T_{i-1,j}\frac{1}{M_4}$$

$$+ T_{i,j}\left[1 - \frac{1}{M_1}\frac{(2J-3)}{2(J-1)} - \frac{1}{M_2} - \frac{1}{M_3}\frac{(2J-1)}{2(J-1)} - \frac{1}{M_4}\right]$$

HERE THE TERMS $\frac{1}{M_1}$, $\frac{1}{M_2}$, $\frac{1}{M_3}$, $\frac{1}{M_4}$ REFER TO THE VALUE OF $\frac{1}{M}$ THAT APPLIES FOR THE CELL i,j AND THE CELL TO THE RIGHT, ABOVE, LEFT, AND BELOW RESPECTIVELY.

NON CORNER AXIAL CELLS, $I = 2$ TO $II-1$, $J = 1$

ENERGY BALANCE:

$$\left(T'_{i,1} - T_{i,1}\right)\frac{c\rho}{\Delta\tau}\frac{\Delta x^3}{8} = \left(T_{i+1,1} - T_{i,1}\right)\frac{k^*}{\Delta x}\frac{\Delta x^2}{8} + \left(T_{i,2} - T_{i,1}\right)\frac{k^*}{\Delta x}\frac{\Delta x^2}{2} + \left(T_{i-1,1} - T_{i,1}\right)\frac{k^*}{\Delta x}\frac{\Delta x^2}{8}$$

TEMPERATURE $T'_{i,1}$

$$T'_{i,1} = T_{i+1,1}\frac{1}{M_2} + T_{i,2}\frac{4}{M_3} + T_{i-1,1}\frac{1}{M_4} + T_{i,1}\left[1 - \frac{1}{M_2} - \frac{4}{M_3} - \frac{1}{M_4}\right].$$

ALL OTHER CELLS HAVE A CONVECTION BOUNDARY. TOP, BOTTOM, AND SIDES ARE ASSUMED TO HAVE A COMMON VALUE FOR THE HEAT TRANSFER COEFFICIENT, h, ALTHOUGH THE COMPUTER PROGRAM WRITTEN TO SOLVE THE PROBLEM WILL ACCEPT VARIABLE VALUES OF h. THEREFORE THE CELLS ARE SYMMETRICAL ABOUT THE PLANE NORMAL TO THE MIDPOINT OF THE AXIS.

NON CORNER, BOTTOM CELLS $I=1$, $J=2$ TO $JJ-1$

(SIMILAR TO NON CORNER, TOP CELLS $I=II$, $J=2$ TO $JJ-1$

$\therefore$

ENERGY BALANCE:

$$\left(T'_{1,j} - T_{1,j}\right)\frac{c\rho}{\Delta\tau}\frac{(J-1)}{2}\Delta X^3 = \left(T_{1,j-1} - T_{1,j}\right)\frac{k^*}{\Delta X}\frac{(2J-3)}{4}\Delta X^2$$

$$+\left(T_{2,j} - T_{1,j}\right)\frac{k^*}{\Delta X}(J-1)\Delta X^2 + \left(T_{1,j+1} - T_{1,j}\right)\frac{k^*}{\Delta X}\frac{(2J-1)}{4}\Delta X^2$$

$$+ \left(T_g - T_{1,j}\right)h\,(J-1)\Delta X^2$$

TEMPERATURE $T'_{1,j}$:

$$T'_{1,j} = T_{1,j-1}\frac{1}{M_1}\frac{(2J-3)}{2(J-1)} + T_{2,j}\frac{2}{M_2} + T_{1,j+1}\frac{1}{M_3}\frac{(2J-1)}{2(J-1)}$$

$$+ T_g\,h\,\frac{2\,\Delta\tau}{\Delta X\,c\rho} + T_{1,j}\left[1 - \frac{(2J-3)}{M_1\,2(J-1)} - \frac{2}{M_2} - \frac{(2J-1)}{M_3\,2(J-1)}\right.$$

$$\left. - \frac{2h\,\Delta\tau}{c\rho\,\Delta X}\right]$$

NON CORNER, SIDE CELLS $I = 2, II-1, J = JJ$

ENERGY BALANCE

$$\left(T'_{i,JJ} - T_{i,JJ}\right)\frac{c\rho}{\Delta\tau}\frac{(4JJ-5)}{8}\Delta X^3 =$$

$$\left(T_{i,JJ-1} - T_{i,JJ}\right)\frac{k^*}{\Delta X}\frac{(2JJ-3)}{2}\Delta X^2$$

$$+\left(T_{i+1,JJ} - T_{i,JJ}\right)\frac{k^*}{\Delta X}\frac{(4JJ-5)}{8}\Delta X^2$$

$$+\left(T_g - T_{i,JJ}\right)h\,(JJ-1)\Delta X^2$$

$$+\left(T_{i-1,JJ} - T_{i,JJ}\right)\frac{k^*}{\Delta X}\frac{(4JJ-5)}{8}\Delta X^2$$

TEMPERATURE $T'_{i,JJ}$

$$T'_{i,JJ} = T_{i,JJ-1}\frac{4(2JJ-3)}{(4JJ-5)M1} + T_{i+1,JJ}\frac{1}{M_2}$$

$$+ T_g\frac{\Delta\tau h}{c\rho\Delta X}\frac{8(JJ-1)}{(4JJ-5)}$$

$$+ T_{i,JJ}\left[1 - \frac{4(2JJ-3)}{M_1(4JJ-5)} - \frac{1}{M_2} - \frac{\Delta\tau h}{c\rho\Delta X}\frac{8(JJ-1)}{(4JJ-5)} - \frac{1}{M_4}\right.$$

CORNER, BOTTOM AXIAL $I=1, J=1$

(SIMILAR TO TOP AXIAL $I=II, J=1$)

ENERGY BALANCE

$$(T'_{1,1} - T_{1,1})\frac{c\rho}{\Delta\tau}\frac{\Delta x^3}{16} = (T_{2,1} - T_{1,1})\frac{k^*}{\Delta x}\frac{\Delta x^2}{8} + (T_{1,2} - T_{1,1})\frac{k^*}{\Delta x}\frac{\Delta x^2}{4} + (T_g - T_{1,1})\,h\,\frac{\Delta x^2}{8}$$

TEMPERATURE $T'_{1,1}$

$$T'_{1,1} = T_{2,1}\frac{2}{M_2} + T_{1,2}\frac{4}{M_3} + T_g\frac{h2\Delta\tau}{\Delta x c\rho} + T_{1,1}\left[1 - \frac{2}{M_2} - \frac{4}{M_3} - \frac{2h\Delta\tau}{\Delta x c\rho}\right]$$

CORNER CELL BOTTOM, SIDE $I=1, J=JJ$

(SIMILAR TO TOP, SIDE $I=II, J=JJ$)

ENERGY BALANCE

$$(T'_{1,JJ} - T_{1,JJ})\frac{c\rho}{\Delta\tau}\frac{(4JJ-5)}{16}\Delta x^3 = (T_{1,JJ-1} - T_{1,JJ})\frac{k^*}{\Delta x}\frac{(2JJ-3)}{4}\Delta x^2 + (T_{2,JJ} - T_{1,JJ})\frac{k^*}{\Delta x}\frac{(4JJ-5)}{8}\Delta x^2 + (T_g - T_{1,JJ})\left[h\frac{(JJ-1)}{2}\Delta x^2 + h\frac{(4JJ-5)}{8}\Delta x^2\right]$$

TEMPERATURE $T'_{1,JJ}$

$$T'_{1,JJ} = \frac{4(2JJ-3)}{(4JJ-5)M_1}T_{1,JJ-1} + T_{2,JJ}\frac{2}{M_2} + T_g\frac{\Delta\tau}{c\rho\Delta x}\left[\frac{8(JJ-1)h}{(4JJ-5)} + 2h\right] + T_{1,JJ}\left[1 - \frac{4(2JJ-3)}{(4JJ-5)M_1} - \frac{2}{M_2} - \frac{8h(JJ-1)\Delta\tau}{(4JJ-5)c\rho\Delta x} - \frac{2h\Delta\tau}{c\rho\Delta x}\right]$$

THE FOLLOWING LIMITATIONS ARE IMPOSED IN THE SOLUTION OF THE PREVIOUS EQUATIONS

1.) AT THE START, THE OVEN AIR TEMPERATU CAN NOT USUALLY BE ALLOWED TO TAKE THE VALUE OF THE INPUTTED MAXIMUM OVEN TEMPERATURE, SINCE THE ΔT BETWEEN THAT TEMPERATURE AND THE FOOD COULD LEAD TO A POWER INPUT GREATER THAN AVAILABLE FROM THE HEATER. CONSEQUENTLY IF THE CALCULATED INPUT POWER EXCEEDS THE HEATER POWER THE AIR TEMPERATURE IS ADJUSTED DOWNWARD TO OBEY THE RESTRICTION.

2) CHANGE OF STATE. WHEN FOOD IN A CELL IS FROZEN AND THE CALCULATED TEMPERATURE FOR THE NEXT INTERVAL $\Delta\mathcal{C}$ GIVES A TEMP. $>32\,^{\circ}F$. THE ENERGY EXCESS ABOVE THAT REQUIRED TO REACH $32\,^{\circ}F$ IS COMPARED TO THE HEAT CAPACITY OF THE CELL. IF THIS ENERGY EXCESS IS INSUFFICIENT TO THAW THE FOOD MASS, THIS ENERGY EXCESS IS STORED, AND THE CELL TEMPERATU

IS HELD AT 32°F UNTIL THE TOTAL ENERGY EXCESS IS SUFFICIENT AND ANY SURPLUS BEYOND THAT IS NOW USED: TO RAISE THE TEMPERATURE ABOVE 32°F.

3) STABILITY CRITERIUM. THE TIME INCREMENT USED IN SOLUTION OF THE TEMPERATURE EQUATIONS MUST BE SMALL ENOUGH SO THAT THE LAST TERM OF THE TEMPERATURE EQUATION, WHICH HAS THE GENERAL FORM $T_{i,j}[1 - C_1 \Delta\tau - C_2 \Delta\tau \ldots]$, WILL NOT TAKE A NEGATIVE VALUE

4) IF THE OVEN LOADING CONTAINS MORE THAN ONE FOOD TYPE, e.g. SOME FROZEN AND SOME AMBIENT TEMPERATURE FOOD, AND IF FURTHER THE HEATER POWER LIMITS THE AIR TEMPERATURE AT THE START, THEN THE TEMPERATURE SOLUTION FOR EACH FOOD TYPE MUST BE SOLVED ALTERNATELY IN EACH TIME INTERVAL, $\Delta\tau$, AND THE

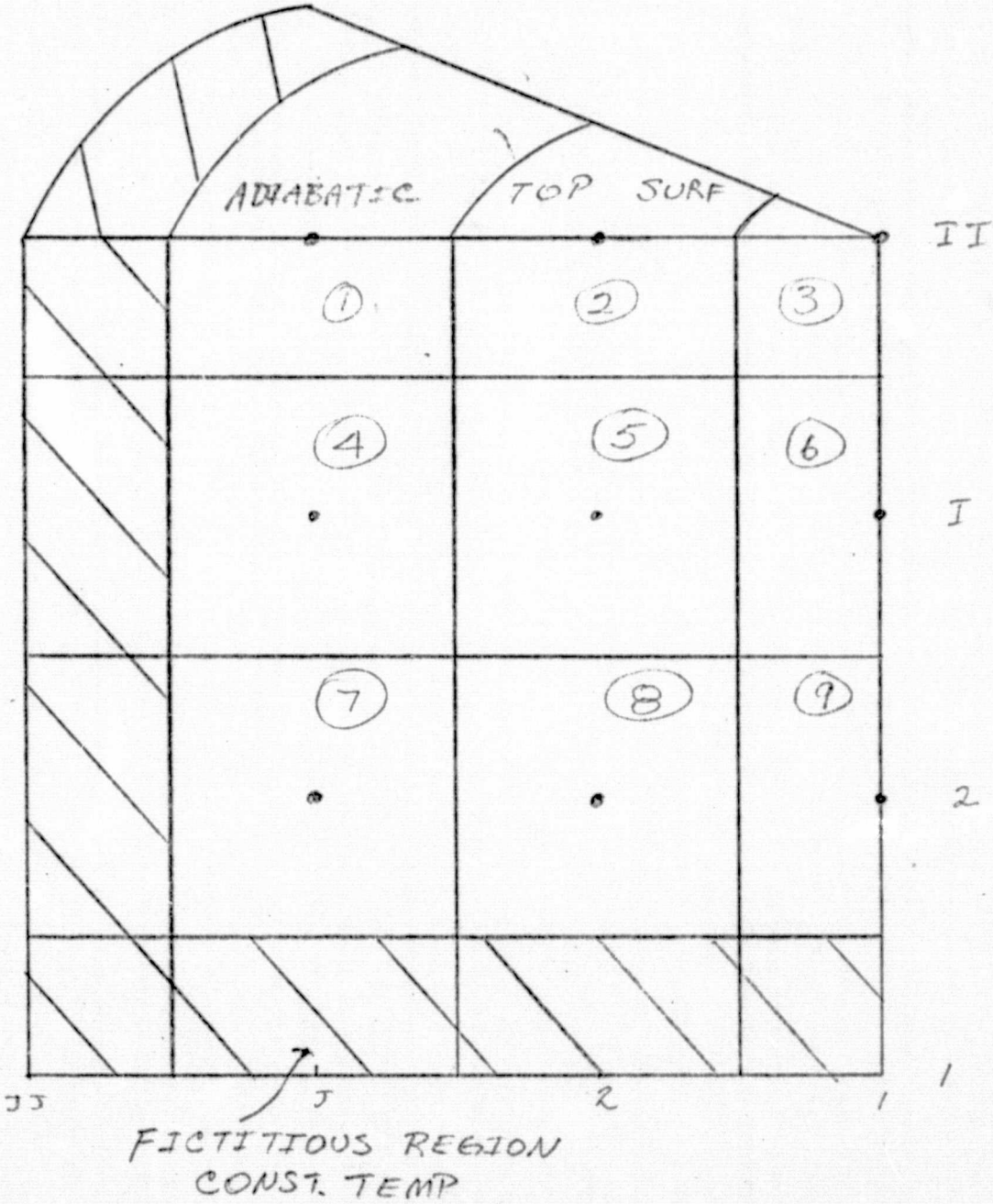
APPROPRIATE ADJUSTMENT IN OVEN AIR TEMPERATURE MADE.

FAIRCHILD
REPUBLIC COMPANY
FARMINGDALE, L.I., NEW YORK 11735

CONDUCTION OVEN

THE TEMPERATURE SOLUTION FOR THE CONDUCTION OVEN IS BASED ON A CONSTANT TEMPERATURE BOUNDARY. THIS IS ACHIEVED BY PLACING A FICTITIOUS REGION AT THE HEATED SURFACES WHICH IS HELD AT THE MAXIMUM HEATER TEMPERATURE. AGAIN IF THE ΔT, HEATER TO CELL, IS SO LARGE AT THE START THAT THE INPUT POWER WOULD EXCEED THE HEATER POWER, THEN THE HEATER LIMIT IS INPOSED. HEAT FLOWS FROM THE FIXED TEMP. BOUNDARY BY CONDUCTION, BUT THE PATH LENGTH FROM TEMPERATURE POINTS IS TAKEN AS $\Delta X/2$, AND ONLY THE CONDUCTIVITY OF THE REAL CELL IS CONSIDERED. TO APPROXIMATE THE EFFECT OF FINGER HOLDS AT THE SIDES OF THE HEATER, SINCE THE GEOMETRY IS ASSUMED AXISYMMETRIC, THE HEAT INPUT AT THE SIDES IS REDUCED BY A CONSTANT FACTOR F (TAKEN AS 0.8). THE BOUNDARY AT UNHEATED SURFACES IS TAKEN AS ADIABATIC.

THE CELL SUBDIVISION IS SHOWN BELOW.



NINE CELL TYPES IDENTIFIED IN THE FIGURE AS ① THRU ⑨ MUST BE CONSIDERED. REGION ⑤, INTERIOR CELLS; AND REGION ⑥ AXIAL, NON CORNER CELLS, ARE IDENTICAL TO THE CONVECTION SOLUTION, SINCE THE BOUNDARY IS NOT INVOLVED.

THE TEMPERATURE SOLUTION FOR THE OTHER CELLS FOLLOW.

① LEFT TOP CORNER $I = II$, $J = JJ-1$

$$T'_{II,JJ-1} = T_{II,JJ-2}\frac{FR_j}{M1} + 2T_f\frac{FL_j}{M3} + T_{II-1,JJ}\frac{2}{M_4}$$

$$+ T_{II,JJ-1}\left[1 - \frac{FR_j}{M_1} - \frac{2FL_j}{M_3} - \frac{2}{M_4}\right]$$

WHERE: $FR_j \equiv \dfrac{(2J-3)}{2(J-1)}$

$$FL_j \equiv \frac{(2J-1)}{2(J-1)}$$

(2) TOP SURFACE, NON CORNERS $I = II, J = 2, JJ-2$

$$T'_{II,j} = T_{II,j-1}\frac{FR_j}{M1} + T_{II,j+1}\frac{FL_j}{M_3} + T_{II-1,j}\frac{2}{M_4} + T_{II,j}\left[1 - \frac{FR_j}{M_1} - \frac{FL_j}{M_3} - \frac{2}{M_4}\right]$$

(3) TOP RIGHT CORNER, $I = II, J = 1$

$$T'_{II,1} = T_{II,2}\frac{1}{M_3} + T_{II-1,1}\frac{2}{M_4} + T_{II,1}\left[1 - \frac{1}{M_3} - \frac{2}{M_4}\right]$$

(4) SIDE, NON CORNER $I = 3, II-1, J = JJ-1$

$$T'_{i,JJ-1} = T_{i,JJ-2}\frac{FR_j}{M_1} + T_{i+1,JJ-1}\frac{1}{M_2} + 2T_f\frac{FL_j}{M_3}F + T_{i-1,JJ-1}\frac{1}{M_4} + T_{i,JJ-1}\left[1 - \frac{FR_j}{M_1} - \frac{1}{M_2} - \frac{2FL_jF}{M_3} - \frac{1}{M_4}\right]$$

(7) BOTTOM LEFT CORNER $I = 2, J = JJ-1$

$$T'_{2,JJ-1} = T_{2,JJ-2}\frac{FR_j}{M_1} + T_{3,JJ-1}\frac{1}{M_2} + 2T_f\frac{FL_j}{M_3}F + \frac{2}{M_1}T_f + T_{2,JJ-1}\left[1 - \frac{FR_j}{M_1} - \frac{1}{M_2} - 2\frac{FL_j}{M_3}F - \frac{2}{M_4}\right]$$

(8) BOTTOM, NON CORNERS $I=2, J=2, JJ-2$

$$T'_{2,j} = T_{2,j-1}\frac{FR_j}{M_1} + T_{3,j}\frac{1}{M_2} + T_{2,j+1}\frac{FL_j}{M_3} + \frac{2}{M_4}T_f + T_{2,j}\left[1 - \frac{FR_j}{M_1} - \frac{1}{M_2} - \frac{FL_j}{M_3} - \frac{3}{M_4}\right]$$

(9) BOTTOM RIGHT CORNER $I=2, J=1$

$$T'_{2,1} = T_{3,1}\frac{2}{M_2} + T_{2,2}\frac{4}{M_3} + \frac{2}{M_4}T_f + T_{2,1}\left[1 - \frac{2}{M_2} - \frac{4}{M_3} - \frac{2}{M_4}\right.$$

FOR THE OVEN WITH FIXED HEATER EXTENDING ½" UP THE SIDES, NO FINGER HOLE WERE USED, AND THE SURFACE ABOVE THE HEATER IS ADIABATIC.

COMPUTER OUTPUT OF FOOD TEMPERATURE AND OVEN POWER

FOR THE CONVECTION OVEN SOLUTIONS, THE FOOD CYLINDER IS DIVIDED INTO 4 AXIAL AND 6 RADIAL DIVISIONS. THE OUTPUT GIVES TEMPERATURES OF THE UPPER RIGHT QUADRANT SHOWN IN FIGURE B-1. FOR AN OVEN LOADING OF 7 FROZEN CANS AND 14 THERMOSTABILIZED CANS, THE FIRST ARRAY FOR A GIVEN TIME IS THE FROZEN CAN, FOLLOWED BY THE THERMOSTABILIZED. AFTER THE FROZEN FOOD REACHES 155°F THE BOUNDARY IS TAKEN AS ADIABATIC, AND NO FURTHER HEAT ENTERS, BUT THE HEAT IN THE FOOT IS REDISTRIBUTED. WHILE THERE IS ANY FROZEN CELLS, THE STABILITY CRITERIUM REQUIRES A SMALL TIME INCREMENT AND USUALLY EVERY 32nd TIME INTERVAL TEMPERATURE ARRAY IS PRINTED. AFTER COMPLETE THAWING, USUALLY EVERY 4th TIME INTERVAL IS PRINTED. AT EACH INTERVAL THE POWER AND ENERGY INPUT

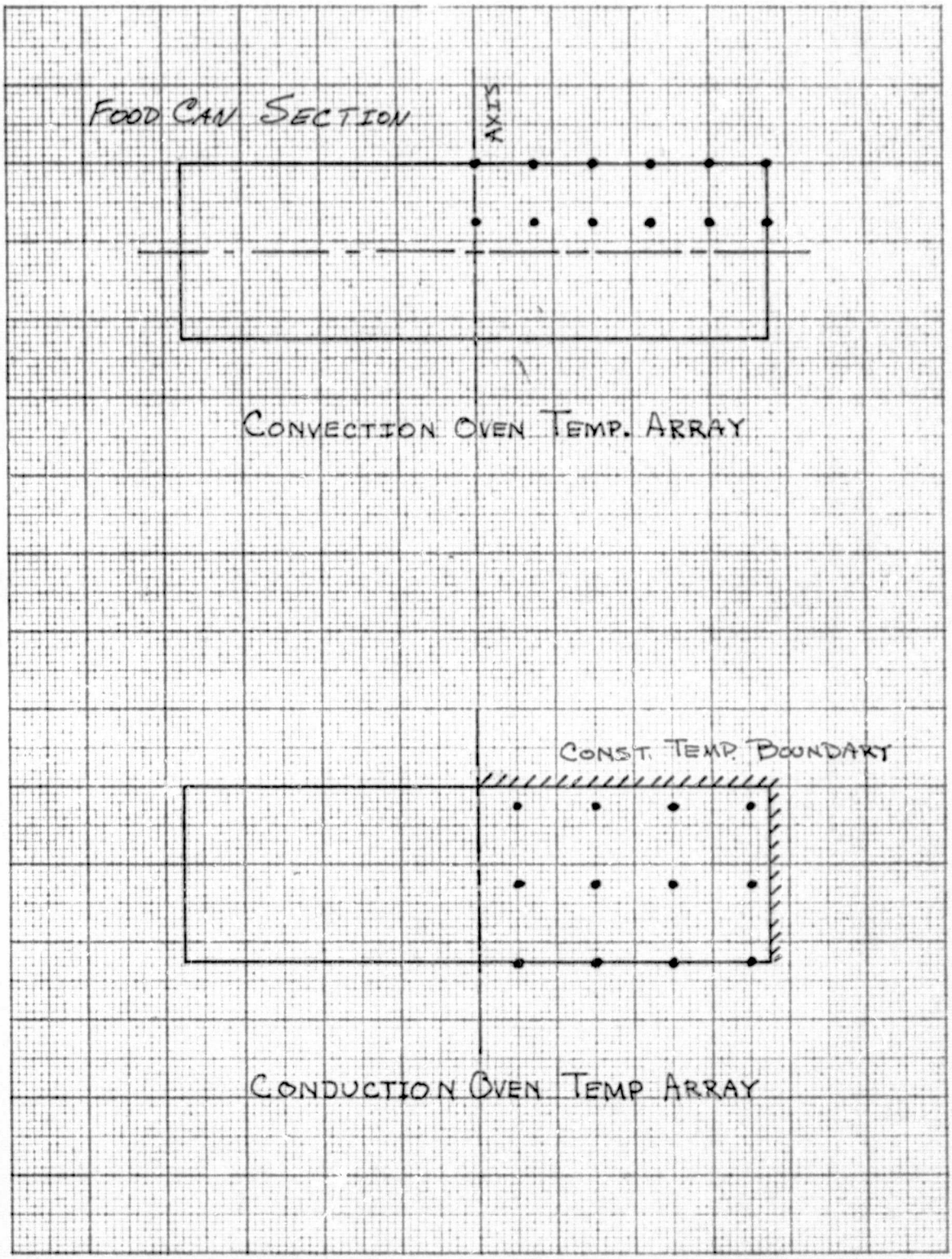


FIGURE B-1 TEMPERATURE ARRAY IN COMPUTER OUTPUT

TO A SINGLE CAN IS PRINTED, AS WELL AS THE MASS AVERAGE TEMPERATURE WHEN ONLY THERMOSTABILIZED CANS ARE HEATED, ONLY A SINGLE TEMP. ARRAY APPEARS FOR ANY TIME INTERVAL.

FOR THE CONDUCTION OVEN, THE FOOD CYLINDER IS DIVIDED INTO 5 AXIAL AND 8 RADIAL DIVISIONS BUT ONLY EVERY OTHER TEMPERATURE POINT IS PRINTED, AS SHOWN IN FIGURE B-1. NOTE THAT THE OUTPUT SHOWS THE HEATED BOTTOM SURFACE AS THE TOP LINE. AGAIN AT EACH INTERVAL THE MASS AVERAGE FOOD TEMPERATURE AND THE POWER AND ENERGY INPUT TO A SINGLE CAN IS PRINTED

Convection Oven, 500W, h = 4, Mixed Load, Slower Heating Food

```
CONVECTION OVEN    AIR TEMP.=180.0 F    H=4.0    MAX POWER= 37.2 WATTS

FOOD PROPERTIES
TEMP.=  0.0
F                                                  1
K=1.09 FROZEN,   .28 THAWED                        1,32,1
C= .43           .80                               0.,180.,155.,4.,4.,37.23
L=109.0                                            500.,1.4
RHO=59.0                                           1.09,.28,.43,.8,109.,59.


THERMOSTAB. FOOD INPUT

2,32,1
70.,180.,155.,4.,4.,17.1
1.25,.3,.47,.91,129.,61.


CONVECTION OVEN    AIR TEMP.=180.0 F    H=4.0    MAX POWER= 17.1 WATTS

FOOD PROPERTIES
TEMP.=  70.0

K=1.25 FRZEN,   .30 THAWED
C= .47          .91
L=129.0
RHO=61.0

TIME=  .03 HRS    T AVE=  31.3 F    POWER= 33.7 WATTS    ENERGY= 2.7 W-HR
TEMP.ARRAY FROZEN 149.  149.
  32.0   32.0   32.0   32.0   32.0   32.0
  29.5   29.7   30.1   30.6   31.3   32.0
TIME=  .03 HRS    T AVE=  82.7 F    POWER= 18.9 WATTS    ENERGY= 1.5 W-HR
TEMP.ARRAY THERMO 155.
  88.3   88.3   88.3   88.6   91.2  103.9
  73.1   73.1   73.2   73.5   76.6   92.1

TIME=  .16 HRS    T AVE=  33.5 F    POWER= 36.7 WATTS    ENERGY= 5.6 W-HR
TEMP.ARRAY FROZEN 165.  162.
  32.0   32.0   32.0   32.0   32.0   55.4
  32.0   32.0   32.0   32.0   32.0   32.0

TIME=  .16 HRS    T AVE=  94.9 F    POWER= 17.4 WATTS    ENERGY= 2.9 W-HR
TEMP.ARRAY THERMO 165.
  98.9   98.9   99.2  100.7  106.2  120.2
  80.6   80.6   81.0   82.9   90.0  107.8
```

TIME= .24 HRS T AVE= 39.3 F POWER= 37.2 WATTS ENERGY= 8.6 W-HR
TEMP.ARRAY FROZEN 180. 173.
32.0 32.0 32.0 32.0 48.9 77.1
32.0 32.0 32.0 32.0 32.0 53.2

TIME= .24 HRS T AVE=106.5 F POWER= 16.2 WATTS ENERGY= 4.3 W-HR
TEMP.ARRAY THERMO 176.
108.2 108.4 109.3 112.0 119.0 133.1
89.0 89.3 90.4 94.0 103.1 121.1
TIME= .32 HRS T AVE= 49.8 F POWER= 30.4 WATTS ENERGY=11.2 W-HR
TEMP.ARRAY FROZEN 180. 191.
58.1 58.3 59.1 61.1 68.2 101.3
32.0 32.0 32.0 32.0 32.0 71.3
TIME= .32 HRS T AVE=117.4 F POWER= 14.8 WATTS ENERGY= 5.5 W-HR
TEMP.ARRAY THERMO 180.
116.8 117.2 118.7 122.4 130.1 143.2
98.2 98.6 100.5 105.3 115.3 132.4

TIME= .40 HRS T AVE= 51.7 F POWER= 29.1 WATTS ENERGY=13.6 W-HR
TEMP.ARRAY FROZEN 180. 199.
63.7 63.8 64.1 65.4 71.9 106.7
32.0 32.0 32.0 32.0 32.0 74.6

TIME= .40 HRS T AVE=126.5 F POWER= 12.4 WATTS ENERGY= 6.6 W-HR
TEMP.ARRAY THERMO 180.
124.0 124.5 126.4 130.6 138.2 149.6
107.1 107.6 110.3 115.8 125.7 140.5
TIME= .48 HRS T AVE= 61.3 F POWER= 26.4 WATTS ENERGY=15.5 W-HR
TEMP.ARRAY FROZEN 180. 206.
64.4 64.4 64.9 67.8 87.5 114.3
32.0 32.0 32.0 32.0 55.5 91.8
TIME= .48 HRS T AVE=134.2 F POWER= 10.6 WATTS ENERGY= 7.5 W-HR
TEMP.ARRA THERMO 180.
130.5 131.2 133.3 137.7 144.7 154.5
115.6 116.5 119.3 124.9 134.1 146.9

TIME= .56 HRS T AVE= 68.1 F POWER= 23.9 WATTS ENERGY=17.8 W-HR
TEMP.ARRAY FROZEN 180. 213.
64.5 64.6 65.5 70.5 98.9 124.4
32.0 32.0 32.0 32.0 69.2 105.5

TIME= .56 HRS T AVE=140.8 F POWER= 9.0 WATTS ENERGY= 8.3 W-HR
TEMP.ARRAY THERMO 180.
136.6 137.3 139.5 143.7 150.1 158.5
123.5 124.4 127.3 132.8 141.1 152.0
TIME= .64 HRS T AVE= 79.7 F POWER= 21.3 WATTS ENERGY=19.6 W-HR
TEMP.ARRA FROZEN 180. 219.
64.7 65.1 68.2 87.6 109.1 131.4
32.0 32.0 32.0 56.0 85.5 115.3
TIME= .64 HRS T AVE=146.3 F POWER= 7.7 WATTS ENERGY= 8.9 W-HR
TEMP.ARRAY THERMO 180.
142.0 142.5 145.0 148.9 154.6 161.8
130.6 131.6 134.4 139.5 146.9 156.3

TIME= .72 HRS T AVE= 92.7 F POWER= 18.5 WATTS ENERGY=21.2 W-HR
TEMP.ARRAY FROZEN 180. 225.
68.0 70.9 83.9 101.9 119.2 138.2
32.0 36.8 52.2 74.4 99.3 124.6

TIME= .72 HRS T AVE=151.1 F POWER= 6.6 WATTS ENERGY= 9.5 W-HR
TEMP.ARRAY THERMO 180.
147.0 147.7 149.7 153.3 158.3 164.5
137.0 137.9 140.6 145.3 151.8 159.8

TIME= .80 HRS T AVE=106.4 F POWER= 15.7 WATTS ENERGY=22.6 W-HR
TEMP.ARRA FROZEN 180. 230.
86.7 90.1 99.4 112.7 128.2 144.3
56.7 61.0 73.2 90.8 111.3 132.7

TIME= .80 HRS T AVE=155.2 F POWER= 5.6 WATTS ENERGY=10.0 W-HR
TEMP.ARRAY THERMO 180.
151.4 152.0 153.9 157.1 161.5 166.8
142.8 143.6 146.0 150.2 155.9 162.8

TIME= .88 HRS T AVE=118.1 F POWER= 13.7 WATTS ENERGY=23.8 W-HR
TEMP.ARRAY FROZEN 180. 235.
103.0 105.5 112.7 123.4 136.1 149.7
78.0 81.4 90.9 105.0 121.9 139.9

TIME= .83 HRS T AVE=158.7 F POWER= 4.8 WATTS ENERGY=10.4 W-HR
TEMP.ARRAY THERMO 180.
155.2 155.8 157.5 160.3 164.1 168.7
147.8 148.5 150.7 154.4 159.4 165.3

TIME= .96 HRS T AVE=128.0 F POWER= 11.5 WATTS ENERGY=24.8 W-HR
TEMP.ARRAY FROZEN 180. 239.
116.0 118.0 123.8 132.4 142.9 154.4
95.3 98.0 105.8 117.0 131.9 148.1

TIME= .96 HRS T AVE=161.7 F POWER= 4.1 WATTS ENERGY=10.7 W-HR
TEMP.ARRAY THERMO 180.
158.6 159.1 160.6 163.1 166.4 170.3
152.2 152.8 154.8 158.0 162.3 167.4

TIME=1.04 HRS T AVE=136.4 F POWER= 9.7 WATTS ENERGY=25.6 W-HR
TEMP.ARRAY FROZEN 180. 242.
126.7 128.4 133.0 140.0 148.8 158.4
109.5 111.6 117.8 127.1 138.6 151.4

TIME=1.04 HRS T AVE=164.3 F POWER= 3.6 WATTS ENERGY=11.0 W-HR
TEMP.ARRATHERMO 180.
161.5 162.0 163.3 165.5 168.4 171.7
156.0 156.6 158.3 161.1 164.9 169.2

TIME=1.12 HRS T AVE=143.4 F POWER= 8.2 WATTS ENERGY=26.3 W-HR
TEMP.ARRAY FROZEN 180. 246.
135.5 136.9 140.6 146.5 153.7 161.8
121.2 122.9 127.9 135.6 145.2 155.9

TIME=1.12 HRS T AVE=166.5 F POWER= 3.1 WATTS ENERGY=11.3 W-HR
TEMP.ARRAY THERMO 180.
164.1 164.5 165.7 167.5 170.0 172.9
159.3 159.8 161.3 163.8 167.0 170.8

C-2

TIME=1.20 HRS T AVE=149.3 F POWER= 6.8 WATTS ENERGY=26.9 W-HR
TEMP.ARRAY FROZEN 180. 248.
142.9 143.9 147.0 151.8 157.9 164.7
130.8 132.3 136.4 142.7 150.7 159.7
TIME=1.20 HRS T AVE=168.4 F POWER= 2.6 WATTS ENERGY=11.5 W-HR
TEMP.ARRAYTHERMO 180.
166.3 166.7 167.7 169.3 171.4 173.9
162.2 162.8 164.7 166.1 168.9 172.1

TIME=1.28 HRS T AVE=154.2 F POWER= 5.8 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 180. 250.
148.9 149.8 152.4 156.4 161.4 167.1
138.9 140.0 143.4 148.7 155.4 162.9
TIME=1.28 HRS T AVE=170.1 F POWER= 2.3 WATTS ENERGY=11.7 W-HR
TEMP.ARRAY THERMO 180.
168.2 168.5 169.4 171.3 172.6 174.8
164.7 165.1 166.2 168.0 170.4 173.2
TIME=1.36 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMP.ARRAYFROZEN 164. 254.
146.9 147.8 150.5 154.7 159.8 162.4
144.6 145.6 148.5 153.0 158.1 161.1
TIME=1.36 HRS T AVE=170.1 F POWER= 0.0 WATTS ENERGY=11.7 W-HR
TEMP.ARRAY THERMO 173.
166.9 167.3 168.2 169.8 171.5 172.5
166.3 166.6 167.6 169.3 171.1 172.1
TIME=1.44 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMP.ARRAY FROZEN 160. 251.
147.4 148.3 150.9 154.6 158.1 159.6
147.1 148.0 150.6 154.3 157.9 159.4

Convection Oven, 500W, h = 4, Mixed Load, Faster Heating Food

```
CONVECTION OVEN   AIR TEMP.=160.0 F   H=4.0   MAX POWER= 37.2 WATTS

FOOD PROPERTIES
TEMP.=  0.0                                    1,32,1
F                                              0.,180.,155.,4.,4.,37.23
K= .97 FROZEN,   .26 THAWED                    300.,1.4
C= .40           .71                           .97,.26,.4,.71,91.,58.
L= 91.0
RHO=58.0


THERMOSTAB. FOOD INPUT

2,32,1
70.,180.,155.,4.,4.,17.1
.99,.26,.4,.74,96.,58.


CONVECTION OVEN   AIR TEMP.=180.0 F   H=4.0   MAX POWER= 17.1 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K= .99 FROZEN,   .26 THAWED
C= .40           .74
L= 96.0
RHO=58.0


TIME= .08 HRS   T AVE= 31.3 F   POWER= 34.4 WATTS   ENERGY= 2.7 W-HR
TEMP.ARRAY FROZEN 151. 151.
  32.0   32.0   32.0   32.0   32.0   32.0
  29.5   29.6   30.0   30.6   31.3   32.0

TIME= .08 HRS   T AVE= 86.3 F   POWER= 18.5 WATTS   ENERGY= 1.5 W-HR
TEMP.ARRAY THERMO 156.
  93.0   93.0   93.0   93.4   96.8  111.4
  74.5   74.5   74.5   75.0   79.2   97.9

TIME= .16 HRS   T AVE= 34.0 F   POWER= 37.3 WATTS   ENERGY= 5.6 W-HR
TEMP.ARRAY FROZEN 169. 168.
  32.0   32.0   32.0   32.0   32.0   63.0
  32.0   32.0   32.0   32.0   32.0   32.0

TIME= .16 HRS   T AVE=101.7 F   POWER= 17.0 WATTS   ENERGY= 2.9 W-HR
TEMP.ARRAY THERMO 172.
 105.9  106.0  106.4  106.4  115.0  130.4
  84.4   84.5   85.1   87.8   96.5  116.9
```

TIME= .24 HRS T AVE= 47.1 F POWER= 32.3 WATTS ENERGY= 8.5 W-HR
TEMP.ARRAY FROZEN 180. 185.
47.0 47.7 49.3 53.7 63.8 95.9
32.0 32.0 32.0 32.0 32.0 67.7

TIME= .24 HRS T AVE=115.8 F POWER= 15.0 WATTS ENERGY= 4.1 W-HR
TEMP.ARRAY THERMO 180.
117.0 117.3 118.5 121.9 129.8 144.3
95.6 95.9 97.5 102.1 112.7 132.1

TIME= .32 HRS T AVE= 52.4 F POWER= 28.7 WATTS ENERGY=10.9 W-HR
TEMP.ARRAY FROZEN 180. 200.
64.6 64.7 65.1 66.6 73.3 108.6
32.0 32.0 32.0 32.0 32.0 76.2

TIME= .32 HRS T AVE=127.4 F POWER= 12.0 WATTS ENERGY= 5.2 W-HR
TEMP.ARRAY THERMO 180.
125.7 126.2 128.0 132.2 140.1 152.2
106.8 107.4 109.9 115.5 126.1 142.5

TIME= .40 HRS T AVE= 60.8 F POWER= 26.3 WATTS ENERGY=13.1 W-HR
TEMP.ARRAY FROZEN 180. 207.
66.4 66.5 66.8 69.3 87.0 115.4
32.0 32.0 32.0 32.0 52.3 90.9

TIME= .40 HRS T AVE=136.7 F POWER= 9.7 WATTS ENERGY= 6.0 W-HR
TEMP.ARRAY THERMO 180.
133.5 134.1 136.3 140.6 147.8 157.8
117.2 118.0 120.9 126.8 136.5 150.0

TIME= .48 HRS T AVE= 69.1 F POWER= 23.3 WATTS ENERGY=15.1 W-HR
TEMP.ARRAY FROZEN 180. 216.
66.6 66.8 67.6 72.5 100.8 126.7
32.0 32.0 32.0 32.0 69.7 107.2

TIME= .48 HRS T AVE=144.3 F POWER= 8.0 WATTS ENERGY= 6.7 W-HR
TEMP.ARRAY THERMO 180.
140.5 141.2 143.4 147.6 153.9 162.0
126.6 127.5 130.6 136.2 144.7 155.7

TIME= .56 HRS T AVE= 82.2 F POWER= 20.4 WATTS ENERGY=16.9 W-HR
TEMP.ARRAY FROZEN 180. 222.
66.8 67.3 70.6 91.5 112.4 134.6
32.0 32.0 32.0 58.7 88.3 118.5

TIME= .56 HRS T AVE=150.6 F POWER= 6.5 WATTS ENERGY= 7.3 W-HR
TEMP.ARRAY THERMO 180.
146.6 147.3 149.5 153.2 158.7 165.4
134.9 135.9 138.8 143.9 151.2 160.3

TIME= .64 HRS T AVE= 98.1 F POWER= 17.1 WATTS ENERGY=15.3 W-HR
TEMP.ARRAY FROZEN 180. 229.
76.1 80.1 90.7 105.9 123.5 142.0
41.7 45.8 59.3 79.7 103.6 128.6

TIME= .64 HRS T AVE=155.7 F POWER= 5.4 WATTS ENERGY= 7.7 W-HR
TEMP.ARRAY THERMO 180.
152.0 152.7 154.6 157.9 162.5 168.1
142.2 143.1 145.7 150.2 156.4 163.9

TIME= .72 HRS T AVE=112.7 F POWER= 14.7 WATTS ENERGY=19.6 W-HR
TEMP.ARRAY FROZEN 180. 234.
96.5 99.3 107.1 119.0 133.2 148.5
67.2 70.9 81.6 97.6 116.8 137.4

TIME= .72 HRS T AVE=159.9 F POWER= 4.4 WATTS ENERGY= 6.1 W-HR
TEMP.ARRAY THERMO 180.
156.6 157.2 158.9 161.8 165.6 170.2
148.4 149.2 151.5 155.4 160.6 166.8

TIME= .80 HRS T AVE=124.7 F POWER= 12.1 WATTS ENERGY=20.7 W-HR
TEMP.ARRAY FROZEN 180. 239.
112.1 114.3 120.5 129.9 141.4 153.9
88.3 91.2 99.6 112.3 127.6 144.7

TIME= .80 HRS T AVE=163.4 F POWER= 3.7 WATTS ENERGY= 6.4 W-HR
TEMP.ARRAY THERMO 180.
160.5 161.0 162.5 164.9 168.2 171.9
153.7 154.4 156.4 159.7 164.0 169.1

TIME= .88 HRS T AVE=134.6 F POWER= 10.0 WATTS ENERGY=21.5 W-HR
TEMP.ARRAY FROZEN 180. 243.
124.7 126.4 131.3 138.8 148.2 158.5
105.2 107.5 114.2 124.4 137.0 150.9

TIME= .88 HRS T AVE=166.3 F POWER= 3.0 WATTS ENERGY= 5.7 W-HR
TEMP.ARRAY THERMO 180.
163.8 164.2 165.5 167.6 170.2 173.4
158.1 158.7 160.4 163.2 166.8 171.0

TIME= .96 HRS T AVE=142.7 F POWER= 8.2 WATTS ENERGY=22.2 W-HR
TEMP.ARRAY FROZEN 180. 247.
134.8 136.2 140.1 146.2 153.8 162.3
119.0 120.8 126.1 134.3 144.6 156.0

TIME= .96 HRS T AVE=168.7 F POWER= 2.5 WATTS ENERGY= 6.9 W-HR
TEMP.ARRAY THERMO 180.
166.6 166.9 168.0 169.7 171.9 174.8
161.8 162.3 163.8 166.1 169.1 172.6

TIME=1.04 HRS T AVE=149.4 F POWER= 6.7 WATTS ENERGY=22.8 W-HR
TEMP.ARRAY FROZEN 160. 250.
143.0 144.1 147.3 152.3 155.5 165.4
130.1 131.6 135.9 142.5 150.9 160.3

TIME=1.04 HRS T AVE=170.6 F POWER= 2.1 WATTS ENERGY= 9.1 W-HR
TEMP.ARRAY THERMO 180.
168.9 169.2 170.1 171.5 173.4 175.5
164.9 165.4 166.6 168.5 171.0 173.9

TIME=1.12 HRS T AVE=154.9 F POWER= 5.5 WATTS ENERGY=23.3 W-HR
TEMP.ARRAY FROZEN 160. 252.
149.8 150.6 153.2 157.2 162.3 168.0
139.1 140.3 143.5 149.2 156.1 163.8

TIME=1.12 HRS T AVE=172.2 F POWER= 1.7 WATTS ENERGY= 9.2 W-HR
TEMP.ARRAY THERMO 180.
170.8 171.0 171.5 173.0 174.5 176.3
167.5 167.9 168.9 170.5 172.6 175.0

TIME=1.20 HRS T AVE=156.1 F POWER= 0.0 WATTS ENERGY=23.4 W-HR
TEMP.ARRAY FROZEN 164. 255.
147.5 148.5 151.2 155.5 160.3 163.1
145.4 146.4 149.3 153.8 159.0 161.8

TIME=1.20 HRS T AVE=172.2 F POWER= 0.0 WATTS ENERGY= 9.2 W-HR
TEMP.ARRAY THERMO 175.
169.5 169.8 170.7 172.0 173.5 174.2
169.1 169.4 170.3 171.6 173.2 173.9

TIME=1.28 HRS T AVE=156.1 F POWER= 0.0 WATTS ENERGY=23.4 W-HR
TEMP.ARRAY FROZEN 161. 252.
148.2 149.1 151.7 155.4 158.8 160.3
148.0 148.9 151.5 155.2 158.6 160.1

TIME=1.28 HRS T AVE=172.2 F POWER= 0.0 WATTS ENERGY= 9.2 W-HR
TEMP.ARRAY THERMO 174.
169.8 170.1 170.9 172.0 173.1 173.5
169.8 170.1 170.9 172.0 173.0 173.4

TIME=1.36 HRS T AVE=156.1 F POWER= 0.0 WATTS ENERGY=23.4 W-HR
TEMP.ARRAY FROZEN 159. 251.
149.9 150.7 152.8 155.6 158.0 159.0
149.8 150.6 152.8 155.6 158.0 158.9

TIME=1.36 HRS T AVE=172.2 F POWER= 0.0 WATTS ENERGY= 9.2 W-HR
TEMP.ARRAY THERMO 173.
170.3 170.6 171.2 172.1 172.8 173.1
170.3 170.6 171.2 172.1 172.8 173.1

Convection Oven, 500W, h = 5, Mixed Load

```
CONVECTION OVEN   AIR TEMP.=180.0 F   H=5.0   MAX POWER= 40.6 WATTS

FOOD PROPERTIES
TEMP.=  0.0
F
K=1.09 FROZEN,   .28 THAWED                    1,32,0
C=  .43          .80                           0.,180.,155.,5.,5.,40.59
L=109.0                                        500.,1.3
RHO=59.0


THERMOSTAB. FOOD INPUT

2,32,0
70.,180.,155.,5.,5.,15.47


CONVECTION OVEN   AIR TEMP.=180.0 F   H=5.0   MAX POWER= 15.5 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN,   .30 THAWED
C=  .47          .91
L=129.0
RHO=61.0


TIME= .08 HRS   T AVE= 31.3 F   POWER= 35.9 WATTS   ENERGY= 2.8 W-HR
TEMP.ARRAY FROZEN 132. 132.
  32.0   32.0   32.0   32.0   32.0   32.0
  29.6   29.7   30.1   30.7   31.3   32.0

TIME= .08 HRS   T AVE= 81.8 F   POWER= 17.8 WATTS   ENERGY= 1.4 W-HR
TEMP.ARRAY THERMO 137.
  87.3   87.3   87.3   87.5   89.8  101.2
  72.9   72.9   72.9   73.2   76.1   90.6

TIME= .16 HRS   T AVE= 33.7 F   POWER= 39.0 WATTS   ENERGY= 5.9 W-HR
TEMP.ARRAY FROZEN 147. 144.
  32.0   32.0   32.0   32.0   32.0   58.2
  32.0   32.0   32.0   32.0   32.0   32.0

TIME= .16 HRS   T AVE= 93.2 F   POWER= 16.2 WATTS   ENERGY= 2.7 W-HR
TEMP.ARRAY THERMO 147.
  97.3   97.3   97.6   98.9  103.7  115.9
  79.9   80.0   80.3   82.1   88.6  105.1
```

TIME= .24 HRS T AVE= 41.6 F POWER= 39.0 WATTS ENERGY= 9.1 W-HR
TEMP.ARRAY FROZEN 164. 156.
32.0 32.0 32.0 36.9 54.5 83.4
32.0 32.0 32.0 32.0 32.0 59.1

TIME= .24 HRS T AVE=104.1 F POWER= 16.2 WATTS ENERGY= 4.0 W-HR
TEMP.ARRAY THERMO 159.
106.3 106.5 107.2 109.6 115.6 127.9
88.0 88.2 89.2 92.5 100.7 117.4

TIME= .32 HRS T AVE= 52.3 F POWER= 35.0 WATTS ENERGY=12.0 W-HR
TEMP.ARRAY FROZEN 177. 174.
64.2 64.4 64.9 66.6 73.2 108.2
32.0 32.0 32.0 32.0 32.0 76.2

TIME=.ARRAY THERMO AVG=116.2 F POWER= 18.2 WATTS ENERGY= 5.4 W-HR
117.6 117.9 119.2 122.3 129.2 142.9
97.0 97.4 99.1 103.4 112.8 131.2

TEMP.ARRAY FROZEN AVG= 73.6 F POWER= 33.6 WATTS ENERGY=14.7 W-HR
69.7 69.8 70.1 71.4 80.7 116.0
32.0 32.0 32.0 32.0 37.7 83.6

TIME= .40 HRS T AVE=127.3 F POWER= 14.9 WATTS ENERGY= 6.7 W-HR
TEMP.ARRAY THERMO 180.
127.0 127.4 129.0 132.8 140.2 152.6
107.1 107.7 109.9 115.1 125.3 142.4

TIME= .48 HRS T AVE= 68.4 F POWER= 28.9 WATTS ENERGY=17.2 W-HR
TEMP.ARRAY FROZEN 180. 195.
70.4 70.5 71.1 75.0 100.3 127.9
32.0 32.0 32.0 32.0 65.1 105.7

TIME= .48 HRS T AVE=136.2 F POWER= 12.1 WATTS ENERGY= 7.7 W-HR
TEMP.ARRAY THERMO 180.
134.2 134.7 136.7 140.7 147.8 158.2
116.7 117.5 120.1 125.7 135.5 149.9

TIME= .56 HRS T AVE= 79.1 F POWER= 25.5 WATTS ENERGY=19.4 W-HR
TEMP.ARRAY FROZEN 180. 202.
70.5 70.8 72.6 87.4 111.4 136.5
32.0 32.0 32.0 48.7 82.0 118.0

TIME= .56 HRS T AVE=143.6 F POWER= 10.0 WATTS ENERGY= 8.6 W-HR
TEMP.ARRAY THERMO 180.
140.6 141.2 143.3 147.3 153.7 162.3
125.5 126.4 129.2 134.7 143.6 155.6

TIME= .64 HRS T AVE= 93.3 F POWER= 21.7 WATTS ENERGY=21.3 W-HR
TEMP.ARRAY FROZEN 180. 209.
71.1 72.7 85.9 103.2 123.0 143.7
32.0 34.4 47.6 71.2 99.4 128.6

TIME= .64 HRS T AVE=149.7 F POWER= 8.3 WATTS ENERGY= 9.3 W-HR
TEMP.ARRAY THERMO 180.
146.3 146.9 149.0 152.7 158.3 165.5
133.4 134.3 137.1 142.3 150.0 160.0

TIME= .72 HRS T AVE=109.0 F POWER= 17.8 WATTS ENERGY=22.8 W-HR
TEMP.ARRAY FROZEN 180. 216.
92.2 95.2 103.8 117.0 133.0 150.0
56.7 60.7 72.5 91.1 113.6 137.6

TIME= .72 HRS T AVE=154.7 F POWER= 6.9 WATTS ENERGY= 9.9 W-HR
TEMP.ARRAY THERMO 180.
151.3 151.9 153.9 157.3 162.1 168.1
140.3 141.2 143.9 148.6 155.2 163.5

TIME= .80 HRS T AVE=122.2 F POWER= 15.2 WATTS ENERGY=24.1 W-HR
TEMP.ARRAY FROZEN 180. 220.
109.2 111.6 118.4 128.8 141.5 155.4
80.1 83.4 93.0 107.7 125.7 145.2

TIME= .80 HRS T AVE=158.9 F POWER= 5.7 WATTS ENERGY=10.4 W-HR
TEMP.ARRAY THERMO 180.
155.7 156.3 158.0 161.0 165.2 170.1
146.4 147.2 149.6 153.8 159.5 166.4

TIME= .88 HRS T AVE=133.0 F POWER= 12.4 WATTS ENERGY=25.2 W-HR
TEMP.ARRAY FROZEN 180. 225.
122.7 124.6 130.0 138.3 148.6 159.9
99.1 101.8 109.4 121.1 135.7 151.6

TIME= .88 HRS T AVE=162.4 F POWER= 4.8 WATTS ENERGY=10.8 W-HR
TEMP.ARRAY THERMO 180.
159.5 160.0 161.6 164.2 167.7 171.8
151.6 152.4 154.5 158.1 163.0 168.7

TIME= .96 HRS T AVE=141.8 F POWER= 10.1 WATTS ENERGY=26.1 W-HR
TEMP.ARRAY FROZEN 180. 229.
133.6 135.1 139.4 146.1 154.4 163.6
114.5 116.6 122.7 132.1 143.9 156.8

TIME= .96 HRS T AVE=165.3 F POWER= 4.0 WATTS ENERGY=11.1 W-HR
TEMP.ARRAY THERMO 180.
162.7 163.2 164.5 166.8 169.7 173.2
156.1 156.8 158.6 161.7 165.8 170.6

TIME=1.04 HRS T AVE=148.9 F POWER= 8.2 WATTS ENERGY=26.8 W-HR
TEMP.ARRAY FROZEN 180. 232.
142.4 143.6 147.0 152.4 159.1 166.6
126.8 128.5 133.4 141.0 150.5 161.1

TIME=1.04 HRS T AVE=167.7 F POWER= -3.3 WATTS ENERGY=11.4 W-HR
TEMP.ARRAY THERMO 180.
165.5 165.9 167.1 169.0 171.5 174.3
159.9 160.5 162.1 164.7 168.2 172.2

TIME=1.12 HRS T AVE=154.7 F POWER= 6.7 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 180. 234.
149.5 150.4 153.2 157.6 163.0 169.1
136.9 138.2 142.2 148.3 156.0 164.6

TIME=1.12 HRS T AVE=169.7 F POWER= 2.8 WATTS ENERGY=11.7 W-HR
TEMP.ARRAY THERMO 180.
167.8 168.2 169.2 170.8 172.9 175.3
163.2 163.6 165.0 167.2 170.1 173.5

TIME=1.20 HRS T AVE=156.0 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMP.ARRAY FROZEN 185. 236.
146.6 147.7 150.7 155.4 160.8 163.9
143.8 144.9 148.2 153.3 159.1 162.4

TIME=1.20 HRS T AVE=169.7 F POWER= 0.0 WATTS ENERGY=11.7 W-HR
TEMP.ARRAY THERMO 173.
166.0 166.4 167.6 169.4 171.5 172.6
165.2 165.6 166.8 168.8 171.0 172.1

TIME=1.28 HRS T AVE=156.0 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMP.ARRAY FROZEN 161. 235.
147.1 148.1 151.0 155.2 159.1 160.8
146.7 147.7 150.6 154.8 158.8 160.5

Convection Oven, 500W, h = 6, Mixed Load

```
CONVECTION OVEN   AIR TEMP.=180.0 F   H=6.0   MAX POWER= 43.9 WATTS

FOOD PROPERTIES
TEMP.=  0.0
F
K=1.09 FROZEN,   .28 THAWED                    1.32,0
C=  .43          .80                           0.,180.,155.,6.,6.,43.95
L=109.0                                        500.,1.1
RHO=59.0


THERMOSTAB. FOOD INPUT

2,32,0
70.,180.,155.,6.,6.,13.75


CONVECTION OVEN   AIR TEMP.=180.0 F   H=6.0   MAX POWER= 13.8 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN,   .30 THAWED
C=  .47          .91
L=129.0
RHO=61.0


TIME=  .03 HRS   T AVE= 31.4 F   POWER= 38.0 WATTS   ENERGY= 3.0 W-HR
TEMP.ARRAY FROZEN 120. 120.
  32.0   32.0   32.0   32.0   32.0   32.0
  29.9   30.0   30.4   30.8   31.4   32.0

TIME=  .08 HRS   T AVE= 81.1 F   POWER= 16.7 WATTS   ENERGY= 1.3 W-HR
TEMP.ARRAY THERMO 125.
  86.3   86.3   86.3   86.5   88.6   96.8
  72.7   72.7   72.7   73.0   75.7   89.3

TIME=  .16 HRS   T AVE= 33.8 F   POWER= 41.1 WATTS   ENERGY= 6.3 W-HR
TEMP.ARRAY FROZEN 134. 132.
  32.0   32.0   32.0   32.0   32.0   60.5
  32.0   32.0   32.0   32.0   32.0   32.0

TIME=  .16 HRS   T AVE= 91.6 F   POWER= 15.2 WATTS   ENERGY= 2.5 W-HR
TEMP.ARRAY THERMO 135.
  95.7   95.8   96.0   97.1  101.3  112.1
  79.3   79.4   79.7   81.4   87.3  102.6
```

TIME= .24 HRS T AVE= 45.1 F POWER= 39.6 WATTS ENERGY= 9.6 W-HR
TEMP.ARRAY FROZEN 155. 145.
41.8 42.3 44.4 49.0 61.2 89.2
32.0 32.0 32.0 32.0 32.0 64.3

TIME= .24 HRS T AVE=101.9 F POWER= 15.5 WATTS ENERGY= 3.7 W-HR
TEMP.ARRAY THERMO 147.
104.7 104.8 105.5 107.5 112.7 123.8
87.0 87.2 88.1 91.0 96.5 114.2

TIME= .32 HRS T AVE= 53.2 F POWER= 35.3 WATTS ENERGY=12.4 W-HR
TEMP.ARRAY FROZEN 164. 162.
67.3 67.4 67.7 69.1 75.1 109.2
32.0 32.0 32.0 32.0 32.0 47.9

TIME= .32 HRS T AVE=113.9 F POWER= 17.8 WATTS ENERGY= 5.1 W-HR
TEMP.ARRAY THERMO 166.
116.3 116.6 117.6 120.3 126.4 139.0
95.8 96.2 97.7 101.6 110.4 128.2

TIME= .40 HRS T AVE= 60.7 F POWER= 37.3 WATTS ENERGY=15.4 W-HR
TEMP.ARRAY FROZEN 178. 173.
73.0 73.1 73.3 74.9 88.1 120.3
32.0 32.0 32.0 32.0 45.0 91.3

TIME= .40 HRS T AVE=125.8 F POWER= 17.0 WATTS ENERGY= 6.5 W-HR
TEMP.ARRAY THERMO 176.
127.2 127.6 128.9 132.2 138.9 151.5
105.9 106.4 108.5 113.2 122.9 140.9

TIME= .48 HRS T AVE= 73.0 F POWER= 31.4 WATTS ENERGY=15.1 W-HR
TEMP.ARRAY FROZEN 180. 187.
75.6 75.7 76.3 80.7 105.5 136.5
32.0 32.0 32.0 32.0 70.6 114.4

TIME= .48 HRS T AVE=136.5 F POWER= 14.0 WATTS ENERGY= 7.8 W-HR
TEMP.ARRAY THERMO 180.
136.3 136.8 138.5 142.1 149.0 160.1
116.3 117.0 119.4 124.7 134.8 151.0

TIME= .56 HRS T AVE= 86.7 F POWER= 26.7 WATTS ENERGY=20.4 W-HR
TEMP.ARRAY FROZEN 180. 195.
76.0 76.3 79.1 99.2 121.1 144.9
32.0 32.0 32.0 58.0 91.1 127.1

TIME= .56 HRS T AVE=144.8 F POWER= 11.1 WATTS ENERGY= 8.7 W-HR
TEMP.ARRAY THERMO 180.
143.2 143.7 145.5 149.3 155.6 164.6
126.0 126.6 129.5 135.0 144.3 157.4

TIME= .64 HRS T AVE=104.5 F POWER= 21.5 WATTS ENERGY=22.3 W-HR
TEMP.ARRAY FROZEN 180. 203.
88.6 91.6 100.6 115.1 132.8 151.9
45.4 49.1 61.3 82.6 109.1 137.7

TIME= .64 HRS T AVE=151.4 F POWER= 9.9 WATTS ENERGY= 9.5 W-HR
TEMP.ARRAY THERMO 180.
149.0 149.6 151.5 155.1 160.6 167.8
134.6 135.5 138.2 143.4 151.5 162.2

TIME= .72 HRS T AVE=120.3 F POWER= 17.9 WATTS ENERGY=23.9 W-HR
TEMP.ARRAY FROZEN 180. 209.
108.4 110.7 117.7 128.7 142.5 157.7
72.5 76.0 86.4 103.0 123.7 146.4

TIME= .72 HRS T AVE=156.8 F POWER= 7.2 WATTS ENERGY=10.1 W-HR
TEMP.ARRAY THERMO 180.
154.2 154.7 156.5 159.7 164.4 170.3
142.1 142.9 145.6 150.3 157.2 165.8

TIME= .80 HRS T AVE=132.7 F POWER= 14.2 WATTS ENERGY=25.1 W-HR
TEMP.ARRAY FROZEN 180. 214.
123.3 125.2 130.8 139.5 150.3 162.3
94.9 97.7 106.1 119.1 135.4 153.4

TIME= .80 HRS T AVE=161.1 F POWER= 5.8 WATTS ENERGY=10.7 W-HR
TEMP.ARRAY THERMO 180.
158.5 159.1 160.7 163.5 167.5 172.2
148.5 149.3 151.7 155.8 161.6 168.6

TIME= .88 HRS T AVE=142.6 F POWER= 11.2 WATTS ENERGY=26.1 W-HR
TEMP.ARRAY FROZEN 180. 218.
135.2 136.7 141.1 147.9 156.5 166.0
112.7 114.9 121.6 131.8 144.7 158.9

TIME= .83 HRS T AVE=164.6 F POWER= 4.7 WATTS ENERGY=11.1 W-HR
TEMP.ARRAY THERMO 180.
162.3 162.7 164.2 166.6 169.9 173.7
154.0 154.7 156.8 160.3 165.1 170.8

TIME= .96 HRS T AVE=150.4 F POWER= 8.9 WATTS ENERGY=26.9 W-HR
TEMP.ARRAY FROZEN 180. 222.
144.6 145.8 149.2 154.6 161.4 168.9
126.8 128.6 133.3 141.9 152.1 163.3

TIME= .96 HRS T AVE=167.5 F POWER= 3.9 WATTS ENERGY=11.4 W-HR
TEMP.ARRAY THERMO 180.
165.4 165.8 167.1 169.1 171.8 174.9
158.6 159.2 161.0 164.0 167.9 172.6

TIME=1.04 HRS T AVE=155.2 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 171. 226.
147.1 148.3 151.5 156.5 162.8 168.1
137.9 139.3 143.5 149.9 157.9 164.4

TIME=1.04 HRS T AVE=168.7 F POWER= 0.0 WATTS ENERGY=11.5 W-HR
TEMP.ARRAY THERMO 174.
164.9 165.3 166.6 168.8 171.5 173.5
162.2 162.7 164.3 166.5 170.0 172.2

TIME=1.12 HRS T AVE=155.2 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 163. 225.
144.4 145.6 149.1 154.2 159.6 162.1
143.0 144.3 147.9 153.2 158.8 161.31

Convection Oven, 300W, h = 4, Mixed Load

```
 CONVECTION OVEN   AIR TEMP.=180.0 F   H=4.0   MAX POWER= 27.7 WATTS

 FOOD PROPERTIES
 TEMP.=  0.0
 F
 K=1.09 FROZEN,   .28 THAWED                    1
 C=  .43          .80                           1,32,1
 L=109.0                                        0.,180.,155.,4.,4.,27.709
 RHO=59.0                                       300.,1.4
                                                1.09,.28,.43,.8,109.,59.


 THERMOSTAB. FOOD INPUT

 2,32,1
 70.,180.,155.,4.,4.,7.574
 1.25,.3,.47,.91,129.,61.


 CONVECTION OVEN   AIR TEMP.=180.0 F   H=4.0   MAX POWER=  7.6 WATTS

 FOOD PROPERTIES
 TEMP.= 70.0
 F
 K=1.25 FROZEN,   .30 THAWED
 C=  .47          .91
 L=129.0
 RHO=61.0


 TIME=  .08 HRS   T AVE=  30.3 F   POWER= 23.1 WATTS   ENERGY= 2.0 W-HR
 TEMP.ARRAY FROZEN 112.  111.
   31.8   32.0   32.0   32.0   32.0   32.0
   25.6   26.1   27.3   28.9   30.5   32.0

 TIME=  .08 HRS   T AVE=  76.2 F   POWER=  9.9 WATTS   ENERGY= 0.7 W-HR
 TEMP.ARRAY THERMO 113.
   79.0   79.0   79.0   79.1   80.4   86.8
   71.5   71.5   71.5   71.6   73.1   80.8

 TIME=  .16 HRS   T AVE=  32.0 F   POWER= 24.6 WATTS   ENERGY= 3.9 W-HR
 TEMP.ARRAY FROZEN 118.  118.
   32.0   32.0   32.0   32.0   32.0   32.0
   31.9   31.9   32.0   32.0   32.0   32.0

 TIME=  .16 HRS   T AVE=  82.6 F   POWER=  9.1 WATTS   ENERGY= 1.5 W-HR
 TEMP.ARRAY THERMO 119.
   84.8   84.8   85.0   85.7   88.5   95.8
   75.3   75.3   75.5   76.4   80.0   89.4
```

TIME= .24 HRS T AVE= 33.2 F POWER= 25.2 WATTS ENERGY= 5.9 W-HR
TEMP.ARRAY FROZEN 124. 123.
32.0 32.0 32.0 32.0 3 .0 51.2
32.0 32.7 32.0 32.0 3 .0 32.0

TIME= .24 HRS T AVE= 88.7 F POWER= 8.8 WATTS ENERGY= 2.2 W-HR
TEMP.ARRAY THERMO 125.
89.6 89.7 90.1 91.5 95.1 102.4
79.7 79.8 80.3 82.2 86.6 96.2

TIME= .32 HRS T AVE= 35.8 F POWER= 25.9 WATTS ENERGY= 8.0 W-HR
TEMP.ARRAY FROZEN 132. 128.
32.0 32.0 32.0 32.0 39.4 56.9
32.0 32.0 32.0 32.0 32.0 42.7

TIME= .32 HRS T AVE= 94.5 F POWER= 8.4 WATTS ENERGY= 2.9 W-HR
TEMP.ARRAY THERMO 129.
94.4 94.6 95.3 97.2 101.2 108.4
84.4 84.6 85.6 88.0 93.2 102.0

TIME= .40 HRS T AVE= 43.9 F POWER= 23.3 WATTS ENERGY= 9.9 W-HR
TEMP.ARRAY FROZEN 141. 138.
46.4 46.7 47.6 50.3 56.5 68.1
32.0 32.0 32.0 32.0 32.0 59.3

TIME= .40 HRS T AVE=100.8 F POWER= 9.6 WATTS ENERGY= 3.6 W-HR
TEMP.ARRAY THERMO 140.
100.3 100.6 101.6 103.8 108.0 115.8
89.4 89.8 91.1 94.0 99.5 109.4

TIME= .48 HRS T AVE= 46.7 F POWER= 22.8 WATTS ENERGY=11.5 W-HR
TEMP.ARRAY FROZEN 146. 146.
55.4 55.5 55.8 56.8 61.8 87.8
32.0 32.0 32.0 32.0 32.0 63.8

TIME= .48 HRS T AVE=107.5 F POWER= 9.6 WATTS ENERGY= 4.4 W-HR
TEMP.ARRAY THERMO 148.
106.7 107.1 108.2 110.7 115.3 123.5
95.1 95.6 97.1 100.3 106.2 116.7

TIME= .56 HRS T AVE= 47.8 F POWER= 23.6 WATTS ENERGY=13.6 W-HR
TEMP.ARRAY FROZEN 151. 152.
57.6 57.6 57.8 58.8 63.9 91.7
32.0 32.0 32.0 32.0 32.0 66.0

TIME= .56 HRS T AVE=114.1 F POWER= 9.5 WATTS ENERGY= 5.2 W-HR
TEMP.ARRAY THERMO 154.
112.6 113.2 114.8 117.2 122.0 130.1
101.1 101.6 103.3 106.8 113.1 123.5

TIME= .64 HRS T AVE= 57.6 F POWER= 23.5 WATTS ENERGY=15.5 W-HR
TEMP.ARRAY FROZEN 162. 159.
59.5 59.6 60.0 62.7 80.3 102.8
32.0 32.0 32.0 32.0 53.5 84.1

TIME= .64 HRS T AVE=127.0 F POWER= 9.7 WATTS ENERGY= 6.9 W-HR
TEMP.ARRAY THERMO 161.
119.0 119.4 120.8 123.7 128.6 136.7
107.8 107.8 109.7 113.3 119.7 130.1

TIME= .72 HRS T AVE= 64.3 F POWER= 22.8 WATTS ENERGY=17.4 W-HR
TEMP.ARRAY FROZEN 170. 167.
61.4 61.5 62.3 66.7 92.0 115.1
32.0 32.0 32.0 32.0 65.1 97.8

TIME= .72 HRS T AVE=127.4 F POWER= 10.0 WATTS ENERGY= 6.7 W-HR
TEMP.ARRAY THERMO 169.
122.7 126.2 127.7 130.6 135.7 144.1
113.5 114.1 116.1 119.9 126.5 137.2

TIME= .80 HRS T AVE= 75.8 F POWER= 22.3 WATTS ENERGY=19.2 W-HR
TEMP.ARRAY FROZEN 178. 175.
63.3 63.7 66.2 83.4 103.3 125.4
32.0 32.0 32.0 52.8 80.0 109.2

TIME= .80 HRS T AVE=134.4 F POWER= 10.3 WATTS ENERGY= 7.5 W-HR
TEMP.ARRAY THERMO 177.
132.6 133.1 134.6 137.7 142.9 151.5
120.1 120.7 122.5 126.7 133.4 144.4

TIME= .88 HRS T AVE= 88.7 F POWER= 19.5 WATTS ENERGY=20.3 W-HR
TEMP.ARRAY FROZEN 180. 184.
65.1 66.9 80.3 97.1 115.5 138.1
32.0 32.0 46.3 70.1 94.7 120.7

TIME= .88 HRS T AVE=141.1 F POWER= 9.1 WATTS ENERGY= 8.3 W-HR
TEMP.ARRAY THERMO 180.
138.9 139.4 141.0 144.1 149.4 157.6
126.8 127.4 129.5 133.6 140.4 151.0

TIME= .96 HRS T AVE=103.0 F POWER= 16.4 WATTS ENERGY=22.3 W-HR
TEMP.ARRAY FROZEN 180. 191.
83.4 86.9 96.4 109.8 125.4 142.2
52.5 57.0 69.4 87.0 107.7 129.9

TIME= .96 HRS T AVE=146.7 F POWER= 7.7 WATTS ENERGY= 9.0 W-HR
TEMP.ARRAY THERMO 180.
143.9 144.4 146.1 149.3 154.3 161.4
133.1 133.8 136.0 140.0 146.6 155.5

TIME=1.04 HRS T AVE=115.4 F POWER= 14.4 WATTS ENERGY=23.5 W-HR
TEMP.ARRAY FROZEN 180. 196.
100.3 102.9 110.1 120.9 133.9 148.1
74.5 77.9 87.5 101.8 119.0 137.7

TIME=1.04 HRS T AVE=151.5 F POWER= 6.6 WATTS ENERGY= 9.5 W-HR
TEMP.ARRAY THERMO 180.
148.4 148.9 150.6 153.6 158.2 164.3
138.9 139.6 141.7 145.7 151.7 159.6

TIME=1.12 HRS T AVE=125.7 F POWER= 12.1 WATTS ENERGY=24.5 W-HR
TEMP.ARRAY FROZEN 180. 202.
113.7 115.7 121.5 130.3 141.2 153.1
92.2 94.9 102.6 114.2 128.6 144.4

TIME=1.12 HRS T AVE=150.5 F POWER= 5.6 WATTS ENERGY=10.0 W-HR
TEMP.ARRAY THERMO 180.
152.4 152.9 154.5 157.4 161.5 166.7
144.1 144.8 146.9 150.6 155.9 162.7

TIME=1.20 HRS T AVE=134.5 F POWER= 10.1 WATTS ENERGY=25.4 W-HR
TEMP.ARRAY FROZEN 180. 208.
124.7 126.4 131.1 138.3 147.3 157.3
106.8 109.0 115.2 124.8 136.7 150.0

TIME=1.20 HRS T AVE=159.0 F POWER= 4.8 WATTS ENERGY=10.4 W-HR
TEMP.ARRAY THERMO 180.
156.0 156.5 158.0 160.6 164.2 168.7
146.8 149.4 151.4 154.7 159.5 165.3

TIME=1.25 HRS T AVE=141.8 F POWER= 8.5 WATTS ENERGY=26.1 W-HR
TEMP.ARRAY FROZEN 180. 209.
133.8 135.2 139.0 145.0 152.5 160.9
116.9 120.6 125.7 133.7 143.6 154.7

TIME=1.28 HRS T AVE=162.0 F POWER= 4.1 WATTS ENERGY=10.8 W-HR
TEMP.ARRAY THERMO 180.
159.2 159.6 161.0 163.3 166.5 170.4
152.9 153.5 155.3 158.3 162.5 167.5

TIME=1.36 HRS T AVE=147.9 F POWER= 7.2 WATTS ENERGY=26.7 W-HR
TEMP.ARRAY FROZEN 180. 213.
126.9 130.3 134.3 139.2 145.2 152.9

TIME=1.36 HRS T AVE=164.5 F POWER= 3.5 WATTS ENERGY=11.1 W-HR
TEMP.ARRAY THERMO 180.
162.0 162.4 163.7 165.7 168.5 171.8
156.6 157.1 158.7 161.4 165.0 169.3

TIME=1.44 HRS T AVE=153.1 F POWER= 6.0 WATTS ENERGY=27.2 W-HR
TEMP.ARRAY FROZEN 180. 215.
147.7 148.6 151.2 155.4 160.6 166.5
137.2 138.4 141.9 147.4 154.3 162.21

ORIGINAL PAGE IS
OF POOR QUALITY

Convection Oven, 700W, h = 4, Mixed Load

```
CONVECTION OVEN   AIR TEMP.=180.0 F   H=4.0   MAX POWER= 46.6 WATTS

FOOD PROPERTIES
TEMP.=  0.0                                    1
F                                              1,32,1
K=1.09 FROZEN,   .28 THAWED                    0.,180.,155.,4.,4.,46.757
C=  .43          .50)                          700,1.3
L=109.0                                        1.09,.28,.43,.5,109.,59.
RHO=59.0


THERMOSTAB. FOOD INPUT

2,32,1
70.,180.,155.,4.,4.,26.622
1.25,.3,.47,.91,129.,61.


CONVECTION OVEN   AIR TEMP.=180.0 F   H=4.0   MAX POWER= 26.6 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN,   .30 THAWED
C=  .47          .91
L=129.0
RHO=61.0


TIME=  .03 HRS   T AVE= 31.5 F   POWER= 42.6 WATTS   ENERGY= 3.5 W-HR
TEMP.ARRAY FROZEN 180. 187.
  32.0   32.0   32.0   32.0   32.0   32.0
  30.4   30.5   30.6   31.1   31.6   32.0

TIME=  .03 HRS   T AVE= 87.9 F   POWER= 23.8 WATTS   ENERGY= 2.1 W-HR
TEMP.ARRAY THERMO 130.
  95.4   95.4   95.4   95.8   99.6  116.7
  74.7   74.7   74.7   75.2   79.5  100.9

TIME=  .16 HRS   T AVE= 34.0 F   POWER= 40.3 WATTS   ENERGY= 6.8 W-HR
TEMP.ARRAY FROZEN 180. 203.
  32.0   32.0   32.0   32.0   32.0   64.2
  32.0   32.0   32.0   32.0   32.0   32.0

TIME=  .16 HRS   T AVE=101.9 F   POWER= 16.8 WATTS   ENERGY= 3.7 W-HR
TEMP.ARRAY THERMO 180.
 105.9  106.0  106.4  108.5  115.6  131.8
  84.2   84.3   84.9   87.6   96.7  117.7
```

TIME= .24 HRS T AVE= 45.6 F POWER= 33.2 WATTS ENERGY= 9.3 W-HR
TEMP.ARRAY FROZEN 180. 217.
41.7 42.6 44.9 50.0 61.1 92.3
32.0 32.0 32.0 32.0 32.0 65.3

TIME= .24 HRS T AVE=113.4 F POWER= 15.7 WATTS ENERGY= 5.1 W-HR
TEMP.ARRAY THERMO 180.
113.7 114.0 115.1 118.6 126.7 140.9
93.9 94.2 95.7 100.2 110.8 129.2

TIME= .32 HRS T AVE= 51.1 F POWER= 29.6 WATTS ENERGY=12.2 W-HR
TEMP.ARRAY FROZEN 180. 229.
61.7 61.9 62.4 64.0 70.6 104.6
32.0 32.0 32.0 32.0 32.0 73.5

TIME= .32 HRS T AVE=123.1 F POWER= 13.3 WATTS ENERGY= 6.2 W-HR
TEMP.ARRAY THERMO 180.
120.9 121.4 123.2 127.4 135.4 147.6
103.1 103.7 106.1 111.6 122.0 137.8

TIME= .40 HRS T AVE= 55.4 F POWER= 28.3 WATTS ENERGY=14.6 W-HR
TEMP.ARRAY FROZEN 180. 235.
64.1 64.2 64.5 66.0 77.5 108.2
32.0 32.0 32.0 32.0 42.1 80.4

TIME= .40 HRS T AVE=131.2 F POWER= 11.3 WATTS ENERGY= 7.2 W-HR
TEMP.ARRAY THERMO 180.
127.6 128.3 130.5 134.9 142.4 152.6
111.9 112.7 115.5 121.4 131.1 144.6

TIME= .48 HRS T AVE= 65.0 F POWER= 25.1 WATTS ENERGY=16.7 W-HR
TEMP.ARRAY FROZEN 180. 243.
64.4 64.5 65.2 69.2 93.7 119.5
32.0 32.0 32.0 32.0 63.1 99.1

TIME= .48 HRS T AVE=138.2 F POWER= 9.6 WATTS ENERGY= 8.0 W-HR
TEMP.ARRAY THERMO 180.
134.0 134.7 137.0 141.4 148.1 157.1
120.1 121.0 124.0 129.7 138.5 150.2

TIME= .56 HRS T AVE= 72.6 F POWER= 22.7 WATTS ENERGY=18.6 W-HR
TEMP.ARRAY FROZEN 180. 249.
64.6 64.8 66.3 78.7 103.1 127.6
32.0 32.0 32.0 44.8 76.5 109.9

TIME= .56 HRS T AVE=144.2 F POWER= 8.2 WATTS ENERGY= 8.7 W-HR
TEMP.ARRAY THERMO 180.
139.7 140.5 142.8 146.9 152.9 160.6
127.6 128.6 131.6 136.2 144.7 154.7

TIME= .64 HRS T AVE= 85.2 F POWER= 20.1 WATTS ENERGY=20.3 W-HR
TEMP.ARRAY FROZEN 180. 255.
64.9 65.7 73.5 93.4 113.9 134.6
32.0 32.0 39.2 64.1 92.1 119.7

TIME= .64 HRS T AVE=149.3 F POWER= 7.0 WATTS ENERGY= 9.3 W-HR
TEMP.ARRAY THERMO 180.
144.9 145.7 147.6 151.6 155.9 163.5
134.4 135.3 138.2 143.0 149.9 156.5

TIME= .72 HRS T AVE= 99.2 F POWER= 17.1 WATTS ENERGY=21.8 W-HR
TEMP.ARRAY FROZEN 180. 261.
75.5 79.9 91.0 106.2 123.4 141.1
43.4 48.3 62.2 82.2 105.0 128.5

TIME= .72 HRS T AVE=153.6 F POWER= 6.0 WATTS ENERGY= 9.6 W-HR
TEMP.ARRAY THERMO 180.
149.6 150.2 152.2 155.6 160.3 165.9
140.4 141.3 143.9 148.3 154.3 161.7

TIME= .80 HRS T AVE=112.1 F POWER= 15.0 WATTS ENERGY=23.1 W-HR
TEMP.ARRAY FROZEN 180. 265.
94.7 97.6 105.8 117.9 132.0 146.9
67.1 70.9 81.8 97.7 116.4 136.2

TIME= .80 HRS T AVE=157.4 F POWER= 5.1 WATTS ENERGY=10.2 W-HR
TEMP.ARRAY THERMO 180.
153.7 154.3 156.1 159.1 163.1 168.0
145.7 146.5 148.9 152.8 158.0 164.3

TIME= .88 HRS T AVE=122.9 F POWER= 12.7 WATTS ENERGY=24.2 W-HR
TEMP.ARRAY FROZEN 180. 270.
109.3 111.6 118.1 127.8 139.4 152.0
86.4 89.4 98.0 110.8 126.3 142.9

TIME= .88 HRS T AVE=160.6 F POWER= 4.4 WATTS ENERGY=10.6 W-HR
TEMP.ARRAY THERMO 180.
157.3 157.8 159.4 162.0 165.5 169.7
150.4 151.1 153.2 156.6 161.2 166.6

TIME= .96 HRS T AVE=132.1 F POWER= 10.6 WATTS ENERGY=25.1 W-HR
TEMP.ARRAY FROZEN 180. 274.
121.2 123.1 128.3 136.1 145.8 156.3
102.2 104.6 111.5 121.9 134.7 148.6

TIME= .96 HRS T AVE=163.3 F POWER= 3.8 WATTS ENERGY=10.9 W-HR
TEMP.ARRAY THERMO 180.
160.4 160.9 162.3 164.6 167.6 171.2
154.5 155.1 156.9 159.9 163.9 168.5

TIME=1.04 HRS T AVE=139.8 F POWER= 9.0 WATTS ENERGY=25.8 W-HR
TEMP.ARRAY FROZEN 150. 277.
131.0 132.5 136.7 143.2 151.2 160.0
115.2 117.1 122.7 131.2 141.8 153.5

TIME=1.04 HRS T AVE=165.7 F POWER= 3.2 WATTS ENERGY=11.2 W-HR
TEMP.ARRAY THERMO 180.
163.1 163.5 164.7 166.7 169.4 172.4
158.0 158.5 160.2 162.8 166.2 170.2

TIME=1.12 HRS T AVE=146.2 F POWER= 7.5 WATTS ENERGY=26.5 W-HR
TEMP.ARRAY FROZEN 150. 280.
139.1 140.3 143.8 149.1 155.7 163.2
125.9 127.4 132.0 139.1 147.9 157.7

TIME=1.12 HRS T AVE=167.7 F POWER= 2.8 WATTS ENERGY=11.4 W-HR
TEMP.ARRAY THERMO 180.
165.4 165.8 166.9 168.6 170.9 173.5
161.0 161.5 162.9 165.2 168.1 171.6

TIME=1.20 HRS T AVE=151.7 F POWER= 6.3 WATTS ENERGY=27.0 W-HR
TEMP.ARRAY FROZEN 150. 282.
145.8 146.8 149.6 154.0 159.6 165.8
134.7 136.0 139.8 145.6 153.0 161.3

TIME=1.20 HRS T AVE=169.4 F POWER= 2.4 WATTS ENERGY=11.6 W-HR
TEMP.ARRAY THERMO 180.
167.5 167.8 168.7 170.2 172.2 174.4
163.7 164.1 165.3 167.3 169.8 172.6

TIME=1.28 HRS T AVE=155.2 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 168. 286.
148.2 149.1 151.7 155.3 160.9 165.3
142.1 143.2 146.3 151.2 157.3 162.4

TIME=1.28 HRS T AVE=170.2 F POWER= 0.0 WATTS ENERGY=11.7 W-HR
TEMP.ARRAY THERMO 174.
167.4 167.7 168.6 170.2 172.1 173.4
165.5 166.2 167.3 169.0 171.1 172.6

TIME=1.36 HRS T AVE=155.2 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMP.ARRAY FROZEN 161. 285.
146.7 147.6 150.3 154.4 158.6 160.6
145.8 146.7 149.5 153.6 158.0 160.01

Convection Oven, 500W, h =4, Thermostabilized Food

CONVECTION OVEN AIR TEMP.=180.0 F H=4.0 MAX POWER= 23.8 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN, .39 THAWED
C= .47 .91
L=129.0
RHO=61.0

TIME= .08 HRS T AVE= 86.3 F POWER= 23.8 WATTS ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
93.3 93.3 93.4 93.7 97.1 113.1
74.1 74.1 74.1 74.6 78.6 98.2

TIME= .16 HRS T AVE=100.6 F POWER= 19.2 WATTS ENERGY= 3.6 W-HR
TEMPERATURE ARRAY
105.0 105.1 105.5 107.4 114.3 130.6
83.4 83.4 83.9 86.4 95.2 116.3

TIME= .24 HRS T AVE=112.4 F POWER= 16.0 WATTS ENERGY= 5.0 W-HR
TEMPERATURE ARRAY
113.0 113.3 114.4 117.7 125.8 140.1
93.0 93.3 94.7 99.1 109.5 128.2

TIME= .32 HRS T AVE=122.2 F POWER= 13.5 WATTS ENERGY= 6.1 W-HR
TEMPERATURE ARRAY
120.2 120.7 122.4 126.6 134.6 147.0
102.3 102.9 105.1 110.6 121.0 137.1

TIME= .40 HRS T AVE=130.5 F POWER= 11.4 WATTS ENERGY= 7.1 W-HR
TEMPERATURE ARRAY
127.0 127.7 129.8 134.3 141.8 152.4
111.1 111.9 114.7 120.5 130.3 144.0

TIME= .48 HRS T AVE=137.6 F POWER= 9.7 WATTS ENERGY= 7.9 W-HR
TEMPERATURE ARRAY
133.4 134.1 136.4 140.8 147.6 156.7
119.4 120.3 123.3 129.0 137.9 149.7

TIME= .56 HRS T AVE=143.6 F POWER= 8.3 WATTS ENERGY= 8.6 W-HR
TEMPERATURE ARRAY
139.2 139.9 142.3 146.4 152.5 160.3
126.9 127.9 130.9 136.3 144.2 154.3

TIME= .64 HRS T AVE=148.8 F POWER= 7.1 WATTS ENERGY= 9.2 W-HR
TEMPERATURE ARRAY
144.5 145.2 147.4 151.2 156.5 163.2
133.8 134.7 137.6 142.5 149.5 158.2

TIME= .72 HRS T AVE=153.2 F POWER= 6.1 WATTS ENERGY= 9.7 W-HR
TEMPERATURE ARRAY
149.2 149.8 151.9 155.3 160.0 165.7
139.9 140.8 143.4 147.8 153.9 161.4

TIME= .80 HRS T AVE=157.0 F POWER= 5.2 WATTS ENERGY=10.2 W-HR
TEMPERATURE ARRAY
153.3 153.9 155.7 158.3 162.9 167.5
145.3 146.1 148.4 152.4 157.7 164.1

TIME= .88 HRS T AVE=160.3 F POWER= 4.5 WATTS ENERGY=10.6 W-HR
TEMPERATURE ARRAY
156.9 157.5 159.1 161.8 165.3 169.5
150.0 150.7 152.8 156.3 160.9 166.4

TIME= .96 HRS T AVE=163.1 F POWER= 3.8 WATTS ENERGY=10.9 W-HR
TEMPERATURE ARRAY
160.1 160.6 162.0 164.3 167.4 171.0
154.1 154.7 156.6 159.6 163.6 168.4

TIME=1.04 HRS T AVE=165.4 F POWER= 3.3 WATTS ENERGY=11.2 W-HR
TEMPERATURE ARRAY
162.8 163.3 164.5 166.6 169.2 172.3
157.7 158.2 159.9 162.5 166.0 170.0

TIME=1.12 HRS T AVE=167.5 F POWER= 2.8 WATTS ENERGY=11.4 W-HR
TEMPERATURE ARRAY
165.2 165.6 166.7 168.4 170.7 173.4
160.8 161.3 162.7 165.0 168.0 171.4

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1
2,32,1
70.,180.,175.,4.,4.,23.8095
1.25,.3,.47,.91,129,.61.
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Convection Oven, 500W, h = 5, Thermostabilized Food

```
CONVECTION OVEN   AIR TEMP.=180.0 F   H=5.0   MAX POWER= 23.8 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN,   .30 THAWED
C= .47           .91
L=129.0
RHO=61.0

TIME= .08 HRS   T AVE= 86.3 F   POWER= 23.5 WATTS   ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
  93.5   93.5   93.6   93.9   97.1   102.4
  74.1   74.1   74.2   74.6   76.6   98.2

TIME= .16 HRS   T AVE=102.5 F   POWER= 23.2 WATTS   ENERGY= 3.8 W-HR
TEMPERATURE ARRAY
 108.4  108.5  108.9  110.7  117.4  134.8
  83.8   83.9   84.4   86.9   95.9  119.4

TIME= .24 HRS   T AVE=118.0 F   POWER= 18.1 WATTS   ENERGY= 5.4 W-HR
TEMPERATURE ARRAY
 118.2  118.4  119.5  122.8  130.9  146.1
  94.9   95.2   96.6  101.2  112.4  133.4

TIME= .32 HRS   T AVE=127.0 F   POWER= 14.8 WATTS   ENERGY= 6.7 W-HR
TEMPERATURE ARRAY
 126.5  126.5  128.2  132.4  140.5  152.2

TIME= .40 HRS   T AVE=135.9 F   POWER= 12.1 WATTS   ENERGY= 7.7 W-HR
TEMPERATURE ARRAY
 133.3  133.9  136.0  140.3  147.6  158.3
 115.4  116.2  119.1  125.2  135.5  150.0

TIME= .48 HRS   T AVE=143.3 F   POWER= 10.0 WATTS   ENERGY= 8.6 W-HR
TEMPERATURE ARRAY
 139.8  140.5  142.7  147.0  153.6  162.3
 124.5  125.4  128.5  134.3  143.5  155.5

TIME= .56 HRS   T AVE=149.4 F   POWER=  8.3 WATTS   ENERGY= 9.3 W-HR
TEMPERATURE ARRAY
 145.7  146.4  148.6  152.5  158.2  165.5
 132.6  133.5  136.5  142.0  149.9  159.9

TIME= .64 HRS   T AVE=154.5 F   POWER=  6.9 WATTS   ENERGY= 9.9 W-HR
TEMPERATURE ARRAY
 150.9  151.5  153.6  157.1  162.0  168.0
 139.7  140.6  143.4  148.3  155.1  163.4

TIME= .72 HRS   T AVE=158.7 F   POWER=  5.8 WATTS   ENERGY=10.4 W-HR
TEMPERATURE ARRAY
 155.4  156.0  157.8  160.9  165.1  170.1
 145.9  146.8  149.3  153.5  159.3  166.3
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2,32,)
70.,180.,175.,5.,5.,23.8095
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Convection Oven, 500W, h = 6, Thermostabilized Food

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CONVECTION OVEN   AIR TEMP.=T( ).0 F   H=6.0   MAX POWER= 23.8 WATTS

FOOD PROPERTIES
TEMP.= 70.0
F
K=1.25 FROZEN,   .30 THAWED
C= .47           .91
L=129.0
RHO=61.0


TIME= .08 HRS   T AVE= 86.3 F   POWER= 23.8 WATTS   ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
  93.7   93.7   93.8   94.1   97.2  111.8
  74.2   74.2   74.2   74.6   78.6   98.3

TIME= .16 HRS   T AVE=102.6 F   POWER= 23.8 WATTS   ENERGY= 3.8 W-HR
TEMPERATURE ARRAY
 109.1  109.2  109.5  111.2  117.5  134.1
  84.0   84.0   84.5   87.0   95.9  119.4

TIME= .24 HRS   T AVE=118.0 F   POWER= 20.5 WATTS   ENERGY= 5.6 W-HR
TEMPERATURE ARRAY
 121.8  122.0  123.0  126.1  134.0  149.9
  95.8   96.1   97.4  101.9  113.4  136.4

TIME= .32 HRS   T AVE=130.0 F   POWER= 16.0 WATTS   ENERGY= 7.0 W-HR
TEMPERATURE ARRAY
 130.5  130.9  132.5  136.4  144.5  157.3
 107.5  108.1  110.4  116.2  128.0  146.5

TIME= .40 HRS   T AVE=139.5 F   POWER= 12.8 WATTS   ENERGY= 8.1 W-HR
TEMPERATURE ARRAY
 137.9  138.5  140.5  144.7  152.0  162.3
 118.4  119.2  122.0  128.2  138.9  154.1

TIME= .48 HRS   T AVE=147.2 F   POWER= 10.3 WATTS   ENERGY= 9.0 W-HR
TEMPERATURE ARRAY
 144.6  145.2  147.3  151.3  157.7  166.0
 128.0  129.0  132.0  138.0  147.3  159.5

TIME= .56 HRS   T AVE=153.3 F   POWER=  8.3 WATTS   ENERGY= 9.7 W-HR
TEMPERATURE ARRAY
 150.4  151.0  153.0  156.7  162.1  168.8
 136.6  137.5  140.5  145.9  153.8  163.7

TIME= .64 HRS   T AVE=158.3 F   POWER=  6.7 WATTS   ENERGY=10.3 W-HR
TEMPERATURE ARRAY
 155.4  156.0  157.9  161.1  165.6  171.0
 143.9  144.8  147.5  152.2  158.9  166.9

TIME= .72 HRS   T AVE=162.3 F   POWER=  5.4 WATTS   ENERGY=10.8 W-HR
TEMPERATURE ARRAY
 159.7  160.2  161.8  164.6  168.3  172.5
 150.2  151.0  153.4  157.4  162.9  169.4
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1
2,32,1
70.,180.,175.,0.,6.,23.8095
1.25,.3,.47,.91,129.,61.
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Conduction Oven, Heater Bot. & Side, 50 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=180.0 F POWER DENSITY=1135.0 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .89
L=107.0
RHO=59.0

TIME= .08 HRS T AVE= 30.1 F POWER= 50.0 WATTS ENERGY= 4.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 37.8
25.1 26.5 29.1 32.0
22.2 24.2 27.9 32.0

TIME= .16 HRS T AVE= 40.1 F POWER= 50.0 WATTS ENERGY= 8.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 46.1 110.5
31.2 31.4 31.8 32.0
30.9 31.1 31.6 32.0

TIME= .24 HRS T AVE= 59.6 F POWER= 45.6 WATTS ENERGY=11.9 W-HR
TEMPERATURE ARRAY
74.3 78.3 87.1 153.7
32.0 32.0 32.0 78.5
31.9 32.0 32.0 68.1

TIME= .32 HRS T AVE= 73.7 F POWER= 41.0 WATTS ENERGY=15.4 W-HR
TEMPERATURE ARRAY
83.6 86.6 122.4 165.8
32.0 32.0 32.0 110.0
32.0 32.0 32.0 81.6

TIME= .40 HRS T AVE= 93.4 F POWER= 34.6 WATTS ENERGY=18.4 W-HR
TEMPERATURE ARRAY
117.6 127.1 146.9 171.5
32.0 32.0 49.8 139.6
32.0 32.0 32.0 119.5

TIME= .48 HRS T AVE=106.2 F POWER= 25.9 WATTS ENERGY=20.8 W-HR
TEMPERATURE ARRAY
141.7 144.9 156.2 174.2
32.0 32.0 73.3 153.7
32.0 32.0 32.0 143.9

TIME= .56 HRS T AVE=117.6 F POWER= 19.6 WATTS ENERGY=22.6 W-HR
TEMPERATURE ARRAY
147.1 151.8 161.7 175.7
45.3 55.9 96.3 160.6
32.0 32.0 65.6 154.1

TIME= .64 HRS T AVE=126.7 F POWER= 15.6 WATTS ENERGY=24.0 W-HR
TEMPERATURE ARRAY
153.8 156.9 165.4 176.7
56.7 67.3 112.2 164.9
32.0 32.0 83.1 159.6

TIME= .72 HRS T AVE=134.5 F POWER= 12.8 WATTS ENERGY=25.1 W-HR
TEMPERATURE ARRAY
156.6 160.2 168.0 177.3
63.2 84.7 124.9 167.0
32.0 32.0 104.5 163.3

TIME= .80 HRS T AVE=142.2 F POWER= 10.6 WATTS ENERGY=26.0 W-HR
TEMPERATURE ARRAY
158.8 163.1 170.1 177.3
76.3 100.4 136.9 170.2
32.0 64.1 119.0 167.0

TIME= .88 HRS T AVE=149.0 F POWER= 8.7 WATTS ENERGY=26.8 W-HR
TEMPERATURE ARRAY
162.0 165.9 171.9 176.2
93.7 114.5 143.4 172.1
32.0 86.6 131.0 169.5

TIME= .93 HRS T AVE=152.8 F POWER= 7.9 WATTS ENERGY=27.2 W-HR
TEMPERATURE ARRAY
163.0 167.2 172.8 177.3
103.0 122.1 147.6 173.0
69.2 101.2 137.0 170.8

TIME=1.01 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
151.9 155.1 167.4 174.8
119.8 133.5 152.8 [illegible]
100.4 118.9 145.4 165.3

TIME=1.09 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
145.2 152.4 162.9 169.5
129.7 [illegible]
116.8 131.7 150.0 161.5

TIME=1.17 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
144.2 150.9 160.1 165.6
136.3 144.5 156.7 162.3
130.5 139.7 152.4 159.9

TIME=1.25 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
145.2 150.8 158.3 162.6
141.0 147.3 155.7 160.5
137.9 144.7 153.8 158.9

TIME=1.33 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
146.3 151.3 157.2 160.5
144.6 149.4 155.3 159.2
142.9 147.9 154.5 158.1

1,61,1
0,,130,,155,,,0,113.
1.09,,28,,43,\,\,0,109,,59.

Conduction Oven, Heater Bot. & Side, 50 W/Can, Thermostabilized Food (Slow)

CONDUCTION OVEN WALL TEMP.=1[illegible] F POWER DENSITY=1135.0 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 70.0 F
K=1.25 FROZEN, .30 THAWED
C= .47 .91
L=129.0
RHO=61.0

TIME= .08 HRS T AVE=103.3 F POWER= 44.6 WATTS ENERGY= 3.2 W-HR
TEMPERATURE ARRAY
126.3 126.3 130.4 162.0
74.0 74.1 78.1 123.8
70.1 70.2 74.3 112.3

TIME= .16 HRS T AVE=127.1 F POWER= 25.4 WATTS ENERGY= 6.7 W-HR
TEMPERATURE ARRAY
153.3 154.2 152.0 173
86.7 88.6 102.9 156.8
73.2 75.1 90.5 151.5

TIME= .24 HRS T AVE=140.3 F POWER= 15.9 WATTS ENERGY= 8.2 W-HR
TEMPERATURE ARRAY
160.6 161.8 166.2 176.5
100.5 105.2 124.1 165.4
81.8 87.4 110.5 161.8

TIME= .32 HRS T AVE=149.2 F POWER= 11.3 WATTS ENERGY= 9.3 W-HR
TEMPERATURE ARRAY
164.3 165.9 170.3 177.6
112.7 119.4 136.3 169.8
94.0 102.5 126.5 166.9

TIME= .40 HRS T AVE=155.8 F POWER= 8.5 WATTS ENERGY=10.0 W-HR
TEMPERATURE ARRAY
167.1 168.8 172.7 175.3
123.8 131.2 148.1 172.5
107.2 116.7 138.6 170.2

TIME= .48 HRS T AVE=160.8 F POWER= 6.6 WATTS ENERGY=10.6 W-HR
TEMPERATURE ARRAY
169.4 171.1 174.3 178.7
133.6 140.7 155.1 174.3
119.7 125.8 147.6 172.5

TIME= .56 HRS T AVE=164.7 F POWER= 5.2 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY
171.4 172.8 175.6 179.0
142.1 148.4 160.5 175.8
130.6 136.8 154.5 174.2

TIME= .64 HRS T AVE=165.1 F POWER= 0.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

163.4	166.3	171.5	175.9
148.7	154.2	164.0	172.1
139.9	146.9	159.4	169.9

TIME= .72 HRS T AVE=165.1 F POWER= 0.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

160.4	163.8	169.3	173.1
152.6	157.4	165.0	170.2
147.1	152.9	162.0	168.2

TIME= .80 HRS T AVE=165.1 F POWER= 0.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

159.7	163.1	168.0	171.0
155.4	159.5	165.4	169.0
152.3	156.8	163.4	167.5

TIME= .88 HRS T AVE=165.1 F POWER= 0.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

160.1	163.0	167.0	169.4
157.6	160.9	165.4	168.1
155.8	159.4	164.2	167.1

TIME= .96 HRS T AVE=165.1 F POWER= 0.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

160.8	163.2	166.4	168.3
159.4	162.0	165.4	167.4
158.3	161.0	164.7	166.8

Conduction Oven, Heater Bot. & Side, 500W Total Power, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.= 400.0 F POWER DENSITY= 540.8 BTU/HR-FT.S

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .90
L=109.0
RHO=59.3

TIME= .08 HRS T AVG= 25.0 F POWER= 23.8 WATTS ENERGY= 1.2 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 32.0
19.9 22.1 26.4 32.0
15.6 16.1 21.3 32.0

TIME= .16 HRS T AVG= 31.6 F POWER= 23.0 WATTS ENERGY= 3.6 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 32.0
30.5 30.9 31.4 32.0
29.9 30.4 31.2 32.0

TIME= .24 HRS T AVG= 33.2 F POWER= 23.6 WATTS ENERGY= 5.7 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 32.0
31.8 31.9 31.9 32.0
31.6 31.8 31.9 32.0

TIME= .32 HRS T AVG= 37.0 F POWER= 23.6 WATTS ENERGY= 7.8 W-HR
TEMPERATURE ARRAY
32.0 32.0 42.1 76.0
32.0 32.0 32.0 32.0
32.0 32.0 32.0 34.2

TIME= .40 HRS T AVG= 43.8 F POWER= 23.6 WATTS ENERGY= 9.9 W-HR
TEMPERATURE ARRAY
49.4 51.4 57.1 91.9
32.0 32.0 32.0 51.6
32.0 32.0 32.0 43.4

TIME= .48 HRS T AVG= 50.4 F POWER= 23.0 WATTS ENERGY=11.4 W-HR
TEMPERATURE ARRAY
56.2 57.1 65.9 111.3
32.0 32.0 32.0 62.3
32.0 32.0 32.0 54.8

TIME= .56 HRS T AVG= 57.4 F POWER= 23.8 WATTS ENERGY=13.2 W-HR
TEMPERATURE ARRAY
57.3 59.1 83.7 133.8
32.0 32.0 32.0 76.9
32.0 32.0 32.0 67.8

TIME= .64 HRS T AVG= 97.4 F POWER= 23.0 WATTS ENERGY=15.7 W-HR
TEMPERATURE ARRAY
56.5 72.1 99.3 151.2
32.0 32.0 32.0 91.6
32.0 32.0 32.0 87.3

TIME= .72 HRS T AVG= 79.2 F POWER= 24.7 WATTS ENERGY=17.1 W-HR
TEMPERATURE ARRAY
79.1 55.4 119.9 144.1
32.0 32.0 50.1 106.8
32.0 32.0 32.0 89.9

TIME= .80 HRS T AVG= 89.0 F POWER= 21.4 WATTS ENERGY=18.9 W-HR
TEMPERATURE ARRAY
90.5 99.7 129.5 166.5
32.0 32.0 64.3 123.3
32.0 32.0 32.0 101.4

TIME= .88 HRS T AVG=100.0 F POWER= 20.5 WATTS ENERGY=20.6 W-HR
TEMPERATURE ARRAY
97.6 110.6 144.1 171.9
32.0 43.5 81.2 136.8
32.0 32.0 54.3 114.9

TIME= .96 HRS T AVG=111.0 F POWER= 13.6 WATTS ENERGY=22.1 W-HR
TEMPERATURE ARRAY
105.0 123.1 152.0 174.4
41.0 54.6 95.2 149.5
32.0 32.0 68.4 133.1

TIME=1.04 HRS T AVG=121.4 F POWER= 17.0 WATTS ENERGY=23.5 W-HR
TEMPERATURE ARRAY
119.9 139.6 161.3 175.9
51.8 63.2 109.3 160.1
32.0 32.0 86.5 147.8

TIME=1.12 HRS T AVG=131.1 F POWER= 14.3 WATTS ENERGY=24.8 W-HR
TEMPERATURE ARRAY
132.1 147.2 169.6 176.9
57.4 81.1 122.2 166.2
32.0 32.0 102.2 153.2

TIME=1.20 HRS T AVG=139.9 F POWER= 11.5 WATTS ENERGY=25.8 W-HR
TEMPERATURE ARRAY
143.0 157.2 169.0 177.6
67.6 96.7 132.9 169.5
32.0 64.4 117.9 156.3

TIME=1.28 HRS T AVG=147.4 F POWER= 9.4 WATTS ENERGY=26.6 W-HR
TEMPERATURE ARRAY
154.7 163.9 171.3 177.1
87.8 111.1 141.8 171.7
32.0 89.1 126.7 160.1

TIME=1.34 HRS T AVE=152.3 F POWER= 0.2 WATTS ENERGY=27.2 W-HR
TEMPERATURE ARRAY
162.1 166.7 172.6 178.4
100.2 121.0 147.3 172.9
65.4 101.1 137.0 172.7

TIME=1.42 HRS T AVE=155.5 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMPERATURE ARRAY
156.9 160.1 168.4 175.6
118.4 132.8 153.4 169.6
96.7 110.1 145.3 166.4

TIME=1.50 HRS T AVE=156.5 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMPERATURE ARRAY
159.7 164.1 164.0 170.3
131.0 140.9 155.6 165.4
117.9 131.2 150.1 162.1

TIME=1.59 HRS T AVE=157.1 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMPERATURE ARRAY
161.3 159.8 162.9 166.4
140.0 146.7 156.9 162.9
130.9 146.1 152.4 166.4

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1,64,1
0.,180.,155.,.3,540.54
1.99,.2?,.43,.8,109.,59.

Conduction Oven, Heater Bot. & Side, 500W Total Power, Thermostabilized Food (Slow)

CONDUCTION OVEN WALL TEMP.=1[illegible] F POWER DENSITY= 540.5 BTU/ft-ft.-hr

FOOD PROPERTIES
TEMP= 70.0 F
K=1.25 FROZEN, .30 THAWED
C= .47 .91
L=129.0
RHO=61.0

TIME= .08 HRS T AVE= 86.3 F POWER= 23.8 WATTS ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
96.8 96.8 98.3 120.4
71.9 71.9 73.9 95.5
70.1 70.1 72.0 93.7

TIME= .16 HRS T AVE=102.6 F POWER= 23.8 WATTS ENERGY= 3.6 W-HR
TEMPERATURE ARRAY
113.4 114.3 121.7 152.8
78.0 78.9 86.2 117.1
71.5 72.4 79.3 110.7

TIME= .24 HRS T AVE=116.2 F POWER= 21.5 WATTS ENERGY= 5.6 W-HR
TEMPERATURE ARRAY
127.1 129.9 142.4 169.7
85.9 88.7 101.4 137.2
75.7 78.5 91.2 127.1

TIME= .32 HRS T AVE=132.0 F POWER= 18.5 WATTS ENERGY= 7.3 W-HR
TEMPERATURE ARRAY
139.3 144.8 159.0 174.7
95.3 100.4 116.2 154.2
82.6 87.7 104.5 143.8

TIME= .40 HRS T AVE=143.6 F POWER= 15.2 WATTS ENERGY= 8.5 W-HR
TEMPERATURE ARRAY
152.5 158.7 167.8 176.3
105.9 112.2 131.1 165.9
91.8 99.1 118.2 159.4

TIME= .48 HRS T AVE=152.1 F POWER= 10.5 WATTS ENERGY= 9.6 W-HR
TEMPERATURE ARRAY
164.1 168.8 171.2 177.9
117.5 125.2 142.7 170.7
102.8 111.3 132.4 165.9

TIME= .56 HRS T AVE=156.1 F POWER= 7.7 WATTS ENERGY=10.3 W-HR
TEMPERATURE ARRAY
168.0 169.5 173.9 178.4
128.6 135.9 151.3 173.2
114.2 123.5 143.0 171.2

TIME= .67 HRS T AVE=162.7 F POWER= 9.9 WATTS ENERGY=10.0 W-HR
TEMPERATURE ARRAY

170.4	171.9	174.2	176.8
137.9	144.5	157.7	174.8
125.4	134.0	151.0	173.3

TIME= .72 HRS T AVE=165.0 F POWER= 9.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

166.6	169.0	173.2	177.6
145.7	151.5	162.4	178.6
135.4	142.9	157.1	171.7

TIME= .80 HRS T AVE=165.0 F POWER= 9.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

161.3	164.6	170.2	174.8
150.7	155.6	164.5	170.9
143.6	150.6	161.6	168.7

TIME= .88 HRS T AVE=165.1 F POWER= 9.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

165.5	168.4	168.5	171.8
154.2	158.4	165.1	169.4
149.8	154.9	162.7	167.6

TIME= .95 HRS T AVE=165.1 F POWER= 9.0 WATTS ENERGY=11.1 W-HR
TEMPERATURE ARRAY

166.0	168.2	167.4	170.0
156.9	160.2	165.3	169.3
154.2	158.1	163.7	167.1

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2,64,1
70.,180.,165.,,,5,540.54
1.25,.3,.47,.91,129.,61.
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Conduction Oven, Heater Bot. & Side, 500W Total Power, Frozen Food (Fast)

CONDUCTION OVEN WALL TEMP.=[illegible] F POWER DENSITY= 540.5 BTU/HR-FT.SQ
FOOD PROPERTIES
TEMP= 0.0 F
K= .97 FROZEN, .26 THAWED
C= .40 .71
L= 91.0
RHO=58.0

TIME= .03 HRS T AVE= 28.3 F POWER= 23.8 WATTS ENERGY= 1.9 W-HR
TEMPERATUE ARRAY
32.0 32.0 32.0 32.0
20.8 22.9 26.9 32.
16.5 19.3 24.9 32.0

TIME= .16 HRS T AVE= 32.4 F POWER= 28.5 WATTS ENERGY= 3.6 W-HR
TEMPERATUR ARRAY
32.0 32.0 32.0 46.3
30.6 30.9 31.4 32.0
30.0 30.4 31.2 32.0

TIME= .24 HRS T AVE= 35.1 F POWER= 23.8 WATTS ENERGY= 5.7 W-HR
TEMPERATURE ARRAY
31.0 31.9 31.9 87.0
31.8 31.8 31.9 32.0

TIME= .32 HRS T AVE= 42.4 F POWER= 23.8 WATTS ENERGY= 7.6 W-HR
TEMPERATUE ARRAY
42.9 46.9 56.1 95.7
32.0 32.0 32.0 47.9
32.0 32.0 32.0 33.2
TEMPERATURE ARRAY T AVE= 50.8 F POWER= 23.8 WATTS ENERGY= 9.5 W-HR
57.3 58.3 A67.1 119.2
32.0 32.0 32.0 62
32.0 32.0 32.0 52.1
TIME= .48 HRS T AVE= 59.1 F POWER= 23.8 WATTS ENERGY=11.4 W-HR
TEMPERATURE ARRAY
59.4 61.3 86.9 139.8
32.0 32.0 32.0 79.3
32.0 32.0 32.0 59.4

TIME= .56 HRS T AVE= 71.4 F POWER= 23.4 WATTS ENERGY=13.3 W-HR
TEMPERATURE ARRAY
66.3 78.5 106.1 150.2
32.0 32.0 32.0 91.1
32.0 32.0 32.0 74.7

TIME= .64 HRS T AVE= 83.8 F POWER= 21.6 WATTS ENERGY=15.1 W-HR
TEMPERATURE ARRAY
86.0 95.8 124.5 166.9
32.0 32.0 53.1 117.3
32.0 32.0 32.0 95.7

TEMPERATURE ARRAY AVE=176.4 F POWER= 20.5 WATTS ENERGY=16.8 W-HR
32.0 32.0 74.3 132.9
32.0 32.0 42.0 111.0
TIME= .80 HRS T AVE=105.2 F POWER= 18.5 WATTS ENERGY=18.4 W-HR
TEMPERATU ARRAY
105.9 122.2 151.9 174.1
32.0 51.0 90.2 147.9
32.0 32.0 61.5 130.4
TIME= .88 HRS T AVE=120.3 F POWER= 16.5 WATTS ENERGY=19.8 W-HR
TEMPERATURE ARRAY
121.0 136.6 161.2 175.3
51.1 62.1 106.9 159.9
32.0 32.0 81.5 147.3

TIME= .96 HRS T AVE=131.0 F POWER= 13.4 WATTS ENERGY=21.0 W-HR
TEMPERATURE ARRAY
135.2 149.6 166.0 176.9
57.6 80.3 121.2 166.2
32.0 32.0 101.6 161.4

TIME=1.04 HRS T AVE=140.3 F POWER= 10.7 WATTS ENERGY=21.9 W-HR
TEMPERATURE ARRAY
147.4 159.2 169.2 177.6
69.6 97.2 132.9 169.6
32.0 64.3 117.0 166.3
TIME=1.12 HRS T AVE=148.2 F POWER= 8.5 WATTS ENERGY=22.7 W-HR
TEMPERATURE ARRAY
159.5 164.9 171.5 178.2
90.3 112.8 142.5 171.8
32.0 88.7 130.5 169.3
TIME=1.20 HRS T AVE=155.4 F POWER= 6.8 WATTS ENERGY=23.3 W-HR
TEMPERATURE ARR Y
164.7 168.3 173.3 178.6
110.4 127.3 150.4 173.6
86.0 110.0 141.2 171.6
TIME=1.28 HRS T AVE=155.9 F POWER= 0.0 WATTS ENERGY=23.3 W-HR
TEMPERATUE ARRAY
158.6 160.4 165.2 172.4
126.2 137.6 154.2 166.9
110.8 126.1 148.3 165.3
TIME=1.36 HRS T AVE=156.7 F POWER= 0.0 WATTS ENERGY=23.3 W-HR
TEMPERATUE ARRAY
163.2 161.1 162.4 167.6
136.8 144.5 156.1 163.6
126.8 137.2 151.9 160.8
TIME=1.44 HRS T AVE=157.1 F POWER= 0.0 WATTS ENERGY=23.3 W-HR
TEMPERATURE ARRAY
160.1 158.2 161.0 164.2
144.2 149.3 156.7 161.6
137.4 144.4 153.9 159.6
TIME=1.52 HRS T AVE=157.6 F POWER= 0.0 WATTS ENERGY=23.3 W-HR
TEMPERATURE ARRAY
159.8 162.2 160.0 162.1
149.2 152.4 157.2 160.2
144.5 149.1 155.3 158.9

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1,24,1
0.,180.,155...3,340.54
.27..20..4..71,91,,38.

Conduction Oven, Heater Bot. & Side, 500W Total Power, Thermostabilized Food (Fast)

CONDUCTION OVEN WALL TEMP.=150.0 F POWER DENSITY= 540.5 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 70.0 F
K= .99 FROZEN, .26 THAWED
C= .40 .74
L= 96.0
RHO=55.0

TIME= .08 HRS T AVE= 91.1 F POWER= 23.8 WATTS ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
103.6 103.7 106.6 133.4
72.8 72.9 75.3 102.6
70.1 70.2 73.1 99.9

TIME= .16 HRS T AVE=111.7 F POWER= 21.9 WATTS ENERGY= 3.6 W-HR
TEMPERATURE ARRAY
124.1 125.6 135.7 157.0
81.2 82.7 92.6 130.1
72.6 74.1 84.1 121.5

TIME= .24 HRS T AVE=129.6 F POWER= 18.4 WATTS ENERGY= 5.4 W-HR
TEMPERATURE ARRAY
141.2 145.3 155.5 174.4
92.0 96.2 112.4 153.4
79.1 83.3 99.5 142.7

TIME= .32 HRS T AVE=143.6 F POWER= 15.2 WATTS ENERGY= 6.7 W-HR
TEMPERATURE ARRAY
157.5 161.9 167.5 176.8
104.8 111.6 130.1 166.4
89.3 96.4 117.4 162.1

TIME= .40 HRS T AVE=152.7 F POWER= 8.7 WATTS ENERGY= 7.5 W-HR
TEMPERATURE ARRAY
165.4 167.3 171.5 177.9
118.6 125.9 145.5 171.1
102.2 111.2 133.1 166.5

TIME= .48 HRS T AVE=159.1 F POWER= 6.3 WATTS ENERGY= 8.1 W-HR
TEMPERATURE ARRAY
168.6 170.3 173.5 178.5
130.5 137.6 152.7 173.6
116.0 125.1 144.7 171.7

TIME= .56 HRS T AVE=163.9 F POWER= 4.8 WATTS ENERGY= 8.5 W-HR
TEMPERATURE ARRAY
171.0 172.4 175.3 178.9
140.4 146.5 159.3 175.3
128.5 136.5 153.1 173.8

TIME= .64 HRS T AVE=167.5 F POWER= 3.6 WATTS ENERGY= 3.3 W-HR
TEMPERATURE ARRAY
172.9 174.1 176.4 179.2
148.6 154.1 164.1 176.4
139.1 146.2 159.3 175.3

TIME= .72 HRS T AVE=170.3 F POWER= 2.3 WATTS ENERGY= 9.1 W-HR
TEMPERATURE ARRAY
174.4 175.4 177.2 179.4
155.3 159.7 167.3 177.2
147.7 153.6 164.0 176.4

TIME= .80 HRS T AVE=171.3 F POWER= 0.9 WATTS ENERGY= 9.1 W-HR
TEMPERATURE ARRAY
168.2 170.4 174.1 178.9
159.9 163.6 169.9 174.6
154.6 159.3 167.2 173.1

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2,64,1
70.,130.,170.,.6,540.54
.99,.26,.4,.74,96.,56.
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Conduction Oven, Heater Bot. & Side, 75 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=1[illegible].0 F POWER DENSITY=1702.5 BTU/HR-FT.SQ
.

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .80
L=109.0
RHO=59.0

TIME= .05 HRS T AVE= 33.2 F POWER= 75.0 WATTS ENERGY= 6.) W-HR
TEMPERATURE ARRAY
32.) 32.) 32.0 88.)
25.9 27.2 29.5 32.)
23.4 25.2 28.4 32.)

TIME= .16 HRS T AVE= 61.0 F, POWER= 64.9 WATTS ENERGY=11.6 W-HR
TEMPERATURE ARRAY
83.7 86.3 97.2 153.2
31.7 31.8 31.9 64.4
31.4 31.8 31.9 73.5

TIME= .24 HRS T AVE= 81.1 F POWER= 49.) WATTS ENERGY=16.2 W-HR
TEMPERATURE ARRAY
109.5 115.8 135.9 167.6
32.) 32.0 32.) 127.0
32.) 32.0 32.) 102.1

TIME= .32 HRS T AVE= 99.2 F POWER= 37.4 WATTS ENERGY=19.2 W-HR
TEMPERATURE ARRAY
141.) 142.5 153.8 172.5
32.) 32.0 53.) 147.7
32.) 32.) 32.0 140.)

TIME= .40 HRS T AVE=109.8 F POWER= 23.7 WATTS ENERGY=21.3 W-HR
TEMPERATURE ARRAY
144.9 147.0 157.7 174.7
32.0 37.8 80.5 156.2
32.0 32.) 47.3 147.7

TIME= .48 HRS T AVE=120.5 F POWER= 18.2 WATTS ENERGY=23.) W-HR
TEMPERATURE ARRAY
150.4 153.8 162.3 176.)
53.5 59.8 100.1 162.)
32.0 32.) 88.9 156.1

TIME= .56 HRS T AVE=128.8 F POWER= 14.7 WATTS ENERGY=24.3 W-HR
TEMPERATURE ARRAY
155.1 155.) 166.2 176.9
60.5 69.4 115.7 165.8
32.) 32.0 91.5 160.8

TIME= .64 HRS T AVE=136.5 F POWER= 12.1 WATTS ENERGY=25.4 W-HR
TEMPERATURE ARRAY
157.2 161.0 168.7 177.3
65.0 88.7 127.9 168.6
32.7 32.0 108.3 164.7

TIME= .72 HRS T AVE=144.1 F POWER= 10.0 WATTS ENERGY=26.2 W-HR
TEMPERATURE ARRAY
159.9 163.9 170.7 177.9
84.4 104.8 137.4 170.8
32.0 88.7 122.8 167.7

TIME= .80 HRS T AVE=150.9 F POWER= 8.2 WATTS ENERGY=27.0 W-HR
TEMPERATURE ARRAY
163.0 166.6 172.3 178.3
98.2 118.3 145.4 172.5
55.0 95.0 133.9 171.1

TIME= .87 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
161.6 165.7 171.3 177.9
113.8 129.3 151.4 172.3
90.6 112.3 142.3 169.9

TIME= .95 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
148.1 154.9 165.1 172.1
126.8 138.3 155.2 168.7
112.0 127.2 148.7 163.2

TIME=1.03 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
145.1 152.0 161.7 167.6
134.4 143.4 156.1 163.7
126.7 137.2 152.0 160.9

TIME=1.11 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
145.4 151.4 159.5 164.3
139.6 146.8 156.2 161.7
135.7 143.4 153.7 159.7

TIME=1.19 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
146.7 151.7 158.2 161.8
143.8 149.1 156.2 160.2
141.6 147.2 154.7 158.9

TIME=1.27 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
148.4 152.2 157.3 161.1
146.8 150.8 156.1 159.0
145.6 149.8 155.2 158.3

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,\,\1,64,1
0.,150.,155...8,1702.5
1.09..28..43,.8.109..59.

Conduction Oven, Heater Bot. & Side, 100 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=15[illegible] F POWER DENSITY=227[illegible] BTU/SQ-FT.SU

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .80
L=109.)
RHO=59.0

TIME= .04 HRS T AVE= 27.2 F POWER=100.0 WATTS ENERGY= 4.0 W-HR
TEMPERATURE ARRAY
32.0 32.) 32.0 43.9
16.4 16.7 24.2 34.)
10.2 15.3 21.1 32.0

TIME= .08 HRS T AVE= 39.7 F) POWER= 91.9 WATTS ENERGY= 7.9 W-HR
TEMPERATURE ARRAY
32.0 32.0 47.5 126.1
26.3 47.5 29.9 32.0
23.9 25.6 25.7 32.0

TIME= .12 HRS T AVE= 61.3 F POWER= 79.5 WATTS ENERGY=11.3 W-HR
TEMPERATURE ARRAY
91.3 [illegible] 103.[illegible] 152.5
31.) 31.3 31.3 [illegible]5.2
30.0 30.5 31.5 [illegible]0.7

TIME= .16 HRS T AVE= 71.9 F POWER= 61.2 WATTS ENERGY=14.1 W-HR
TEMPERATURE ARRAY 6.9 162.7
31.8 31.9 32.0 111.3
31.6 31.7 31.9 105.5

TIME= .20 HRS T AVE= 83.2 F POWER= 48.) WATTS ENERGY=16.3 W-HR
TEMPERATURE ARRAY
119.9 122.7 136.2 167.6
32.0 32.0 32.) 129.6
31.9 32.0 32.0 114.0

TIME= .24 HRS T AVE= 93.3 F POWER= [illegible]7.7 WATTS ENERGY=18.) W-HR
TEMPERATURE ARRAY
135.[illegible] 137.6 145.[illegible] 170.7
32.0 32.0 32.0 141.[illegible]
32.0 32.) 32.0 133.5

TIME= .28 HRS T AVE= 99.5 F POWER= 29.9 WATTS ENERGY=19.6 W-HR
TEMPERATURE ARRAY
141.9 143.) 150.7 172.6
32.) 32.0 32.9 146.3
32.0 32.0 32.) 141.3

TIME= .32 HRS T AVE=103.8 F POWER= 26.3 WATTS ENERGY=20.4 W-HR
TEMPERATURE ARRAY
144.1 145.3 154.8 173.5
32.0 32.0 63.0 153.0
32.0 32.0 32.0 144.8

TIME= .36 HRS T AVE=110.3 F POWER= 23.5 WATTS ENERGY=21.4 W-HR
TEMPERATURE ARRAY
145.0 147.2 157.3 174.7
32.0 39.1 81.3 156.4
32.0 32.0 51.0 145.3

TIME= .40 HRS T AVE=116.3 F POWER= 20.6 WATTS ENERGY=22.3 W-HR
TEMPERATURE ARRAY
147.1 150.3 160.6 175.4
46.0 53.7 92.9 159.6
32.0 32.0 63.4 153.0

TIME= .44 HRS T AVE=120.9 F POWER= 18.1 WATTS ENERGY=23.0 W-HR
TEMPERATURE ARRAY
150.9 154.0 162.9 176.0
54.2 60.3 100.7 162.2
32.0 32.0 69.5 156.4

TIME= .48 HRS T AVE=125.1 F POWER= 16.1 WATTS ENERGY=23.7 W-HR
TEMPERATURE ARRAY
153.5 156.4 164.7 176.5
58.3 65.8 109.3 164.2
32.0 32.0 75.4 158.8

TIME= .52 HRS T AVE=129.2 F POWER= 14.6 WATTS ENERGY=24.3 W-HR
TEMPERATURE ARRAY
155.7 160.1 166.3 166.9
32.0 32.0 81.3 161.0

TIME= .56 HRS T AVE=133.3 F POWER= 13.2 WATTS ENERGY=24.9 W-HR
TEMPERATURE ARRAY
156.4 159.7 167.6 177.2
62.6 62.0 122.6 167.4
32.0 32.0 101.3 163.1

TIME= .60 HRS T AVE=136.9 F POWER= 12.0 WATTS ENERGY=25.4 W-HR
TEMPERATURE ARRAY
157.3 161.4 168.7 144.3
32.0 37.3 108.9 164.9

TIME= .64 HRS T AVE=140.9 F POWER= 10.9 WATTS ENERGY=25.8 W-HR
TEMPERATURE ARRAY
158.4 162.6 169.3 177.7
76.3 97.3 133.2 169.8
32.0 60.2 116.3 166.4

TIME= .66 HRS T AVE=147.4 F POWER= 9.9 WATTS ENERGY=26.2 W-HR
TEMPERATURE ARRAY
160.0 164.0 170.7 176.0
85.2 105.4 137.8 170.8
32.0 69.3 123.1 167.8

TIME= .72 HRS T AVE=147.9 F POWER= 9.0 WATTS ENERGY=26.6 W-HR
TEMPERATURE ARRAY
161.6 165.4 171.6 176.2
91.9 112.3 142.0 171.8
32.0 64.7 129.0 169.1

TIME= .78 HRS T AVE=152.6 F POWER= 7.9 WATTS ENERGY=27.1 W-HR
TEMPERATURE ARRAY
163.7 167.8 172.7 178.4
102.7 121.7 147.3 172.9
60.6 [illegible] 136.5 170.7

TIME= .82 HRS T AVE=155.6 F POWER= 7.2 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
165.2 168.5 173.4 178.6
111.6 127.8 150.6 173.6
86.9 110.1 141.2 171.6

TIME= .86 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
154.2 159.9 168.5 175.6
119.7 138.3 153.5 169.6
99.9 118.4 145.2 166.3

TIME= .90 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
149.0 155.6 165.7 172.8
125.6 137.4 155.0 167.2
110.2 125.6 140.1 163.7

TIME= .94 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
146.3 153.3 163.6 170.3
130.0 140.5 155.7 165.4
118.6 131.5 150.1 162.1

TIME= .98 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
145.2 152.1 162.0 168.1
133.6 142.9 156.0 164.0
125.2 136.2 151.6 161.1

TIME=1.02 HRS T AVE=155.6 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
144.9 151.6 160.8 165.2
136.6 144.8 156.1 162.9
130.5 139.8 152.7 160.4

1
1,32,1
0,,100,,155,,,0,227).
1.00,,20,,43,,8,109,,59.

Conduction Oven, Heater Bot. & 1/2" Side, 50 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=[illegible] F POWER DENSITY=1451.0 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .26 THAWED
C= .43 .80
L=109.0
RHO=59.0

TIME= .04 HRS T AVE= 29.6 F POWER= 50.0 WATTS ENERGY= 2.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 32.0
14.3 15.0 17.0 20.9
7.4 8.1 9.3 11.7

TIME= .08 HRS T AVE= 29.4 F POWER=150.0 WATTS ENERGY= 4.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 81.7
23.3 23.9 25.1 26
19.7 20.4 21.6 22.7

TIME= .12 HRS T AVE= 36.0 F POWER= 50.0 WATTS ENERGY= 6.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 122.2
27.8 28.2 29.2 32.0
26.1 26.5 27.2 28.0

TIME= .16 HRS T AVE= 45.3 F POWER= 42.8 WATTS ENERGY= 7.8 W-HR
TEMPERATURE ARRAY
59.3 61.7 77.3 148.4
30.6 31.0 31.3 32.0
29.7 30.0 30.6 31.1

TIME= .20 HRS T AVE= 55.0 F POWER= 40.7 WATTS ENERGY= 9.5 W-HR
TEMPERATURE ARRAY
83.3 89.2 97.0 156.2
31.7 31.8 31.9 32.0
31.4 31.5 31.7 31.8

TIME= .24 HRS T AVE= 59.8 F POWER= 37.5 WATTS ENERGY=11.0 W-HR
TEMPERATUE ARRAY
93.2 94.8 113.3 161.2
31.9 31.9 32.0 35.8
31.9 31.9 31.9 32.0

TIME= .28 HRS T AVE= 66.7 F POWER= 33.2 WATTS ENERGY=12.5 W-HR
TEMPERATU ARRAY
99.6 107.0 134.5 165.9
32.0 32.0 32.0 93.6
32.0 32.0 32.0 32.0

TIME= .32 HRS T AVE= 72.8 F POWER= 29.7 WATTS ENERGY=13.7 W-HR
TEMPERATURE ARRAY
125.7 132.2 143.1 166.1
32.0 32.0 32.0 [illegible]
32.0 32.0 32.0 32.8

TIME= .36 HRS T AVE= 76.4 F POWER= 24.6 WATTS ENERGY=14.8 W-HR
TEMPERATURE ARRAY
139.3 141.4 147.3 162
32.0 32.0 32.0 32.9

TIME= .40 HRS T AVG= 72.1 F POWER= 22.7 WATTS ENERGY=15.7 W-HR
TEMPERATURE ARRAY
143.3 144.3 150.4 170.4
32.0 32.0 46.7 69.3
32.0 32.0 32.0 32.0

TIME= .44 HRS T AVG= 81.4 F POWER= 21.3 WATTS ENERGY=16.6 W-HR
TEMPERATURE ARR
144.7 145.7 153.1 170.9
32.0 32.0 53.9 71
32.0 32.0 32.0 32.3

TIME= .48 HRS T AVG= 85.4 F POWER= 20.0 WATTS ENERGY=17.4 W-HR
TEMPERATURE ARRAY
145.9 148.5 155.2 171.4
41.8 45.1 56.9 76.2
32.0 32.0 32.0 32.0

TIME= .52 HRS T AVG= 88.2 F POWER= 19.5 WATTS ENERGY=18.2 W-HR
TEMPERATUE ARRAY
149.5 151.7 156.9 172.0
52.0 55.2 62.1 85.6
32.0 32.0 32.0 32.0

TIME= .56 HRS T AVG= 91.2 F POWER= 17.3 WATTS ENERGY=18.9 W-HR
TEMPERATUR ARRAY
152.4 153.9 158.1 172.4
56.6 58.6 65.4 91.3
32.0 32.0 32.0 32.0

TIME= .60 HRS T AVG= 93.2 F POWER= 16.4 WATTS ENERGY=19.6 W-HR
TEMPERATURE ARRAY
154.2 155.3 159.1 172.8
59.0 60.5 69.8 94.2
32.0 32.0 32.0 32.0

TIME= .64 HRS T AVG= 95.2 F POWER= 15.8 WATTS ENERGY=20.2 W-HR
TEMPERATURE ARRAY
155.2 156.2 160.1 173.1
60.4 61.9 77.5 97.0
32.0 32.0 32.0 32.0

TIME= .68 HRS T AVG= 97.9 F POWER= 15.2 WATTS ENERGY=21.0 W-HR
TEMPERATURE ARRAY
155.9 156.8 161.0 173.4
61.2 63.9 81.9 99.9
32.0 32.0 32.0 43.2

TIME= .72 HRS T AVG=101.2 F POWER= 14.6 WATTS ENERGY=21.9 W-HR
TEMPERATURE ARRAY
156.3 157.6 161.8 173.7
62.0 71.9 86.0 103.6
32.0 32.0 32.0 52.4

TIME= .76 HRS T AVG=104.9 F POWER= 14.0 WATTS ENERGY=22.9 W-HR
TEMPERATURE ARRAY
156.9 158.5 162.6 173.9
71.1 76.5 89.9 107.1
32.0 32.0 32.0 62.5

TIME= .80 HRS T AVE=102.9 F POWER= 13.3 WATTS ENERGY=22.5 W-HR
TEMPERATURE ARRAY
156.1 159.6 163.3 174.2
73.4 83.0 94.3 111.9
32.0 32.0 50.0 71.0

TIME= .84 HRS T AVE=112.7 F POWER= 12.6 WATTS ENERGY=23.1 W-HR
TEMPERATURE ARRAY
159.3 160.6 164.1 174.4
82.7 86.6 99.2 116.1
32.0 32.0 63.1 78.9

TIME= .88 HRS T AVE=116.8 F POWER= 11.9 WATTS ENERGY=23.5 W-HR
TEMPERATURE ARRAY
160.2 161.4 165.0 174.9
85.6 90.4 104.2 120.3
32.0 43.6 71.5 86.2

TIME= .92 HRS T AVE=121.1 F POWER= 11.2 WATTS ENERGY=24.0 W-HR
TEMPERATURE ARRAY
161.0 162.3 165.9 175.2
88.2 93.5 109.3 124.3
37.1 59.0 80.5 93.0

TIME= .94 HRS T AVE=123.6 F POWER= 11.0 WATTS ENERGY=24.3 W-HR
TEMPERATURE ARRAY
161.4 162.8 166.3 175.4
90.6 98.7 112.1 126.5
50.4 66.6 85.2 99.6

TIME= .98 HRS T AVE=127.9 F POWER= 10.3 WATTS ENERGY=24.7 W-HR
TEMPERATURE ARRAY
162.2 163.8 167.2 175.7
96.9 104.6 116.9 130.2
66.1 77.6 92.5 102.7

TIME=1.02 HRS T AVE=131.9 F POWER= 9.7 WATTS ENERGY=25.1 W-HR
TEMPERATURE ARR
163.3 164.8 168.1 176.0
103.6 110.4 121.5 133
77.7 86.8 99.6 110.4

TIME=1.06 HRS T AVE=135.6 F POWER= 9.0 WATTS ENERGY=25.4 W-HR
TEMPERATURE ARRAY
164.5 165.9 169.0 176.3
110.0 116.0 125.9 137.
87.3 94.9 105.9 113.6

TIME=1.10 HRS T AVE=139.0 F POWER= 8.3 WATTS ENERGY=25.8 W-HR
TEMPERATURE ARRAY
165.7 166.9 169.7 176.5
115.9 121.1 130.0 140.3
95.6 102.0 111.6 118.6

TIME=1.14 HRS T AVE=142.2 F POWER= 7.7 WATTS ENERGY=26.1 W-HR
TEMPERATURE ARRAY
166.8 168.0 170.5 176.8
121.3 125.9 133.6 143.2
102.9 109.5 116.9 123.1

TIME=1.18 HRS T AVE=145.2 F POWER= 7.1 WATTS ENERGY=26.4 W-HR
TEMPERATURE ARRAY
167.9 168.9 171.2 177.0
126.2 130.2 137.4 146.0
109.5 114.3 121.5 127.4
TIME=1.22 HRS T AVE=147.9 F POWER= 6.6 WATTS ENERGY=26.7 W-HR
TEMPERATURE ARRAY
168.9 169.3 171.2 177.2
130.7 134.2 140.7 148.5
115.4 119.6 126.3 131.4

TIME=1.26 HRS T AVE=150.4 F POWER= 6.1 WATTS ENERGY=26.9 W-HR
TEMPERATURE ARRAY
169.8 170.6 172.5 177.9
134.8 137.9 143.7 15
120.7 124.9 131.9 130.1

TIME=1.30 HRS T AVE=152.7 F POWER= 5.6 WATTS ENERGY=27.1 W-HR
TEMPERATURE ARRAY
170.6 171.4 173.1 177.6
136.5 141.3 146.5 153
125.6 129.0 134.3 136.4
TIME=1.34 HRS T AVE=154.8 F POWER= 5.1 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
171.4 172.1 173.6 177.8
141.9 144.4 149.1 155.
130.0 133.1 137.9 141.8
TIME=1.38 HRS T AVE=156.3 F POWER= 4.7 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
166.2 167.3 169.0 174.1
144.9 147.2 151.5 156.3
134.1 136.8 141.2 144.6
TIME=1.42 HRS T AVE=155.3 F POWER= 20.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
162.0 163.4 166.5 169.7
147.0 149.2 153.0 156.4
137.8 140.2 144.2 147.1
TIME=1.46 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
159.4 161.0 164.1 166.5
148.5 150.4 153.9 156.4
141.0 143.2 146.7 149.2

TIME=1.50 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
157.6 159.3 162.1 164.1
149.5 151.4 154.3 156.4
143.7 145.7 148.7 150.5

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1,32,1
0.,180.,155.,1.,1451.
1.09,.28,.43,.8,109.,59.

Conduction Oven, Heater Bot. & 1/2" Side, 50 W/Can, Thermostabilized Food (Slow)

CONDUCTION OVEN WALL TEMP.=1[illegible].0 F POWER DENSITY=1451.0 BTU/HR-FT.S

FOOD PROPERTIES
TEMP= 70.0 F
K=1.25 FROZEN, .30 THAWED
C= .47 .91
L=129.0
RHO=61.0

TIME= .06 HRS T AVE= 99.7 F POWER= 31.5 WATTS ENERGY= 3.5 W-HR
TEMPERATURE ARRAY
140.5 140.7 144.1 167.6
75.1 75.1 76.9 91.8
70.2 70.2 70.3 71.4

TIME= .10 HRS T AVE=114.3 F POWER= 17.1 WATTS ENERGY= 5.2 W-HR
TEMPERATURE ARRAY
156.2 156.7 159.9 173.2
89.5 90.3 95.8 110.7
73.8 74.1 76.3 80.6

TIME= .24 HRS T AVE=124.2 F POWER= 13.0 WATTS ENERGY= 6.3 W-HR
TEMPERATURE ARRAY
161.4 162.0 164.8 174.8
102.1 103.7 111.0 122.3
82.4 83.6 87.7 92.9

TIME= .32 HRS T AVE=132.2 F POWER= 10.7 WATTS ENERGY= 7.3 W-HR
TEMPERATURE ARRAY
164.4 165.1 167.9 175.7
112.4 114.5 120.5 131.0
92.9 94.9 99.8 104.8

TIME= .40 HRS T AVE=138.9 F POWER= 9.1 WATTS ENERGY= 8.1 W-HR
TEMPERATURE ARRAY
166.6 167.3 169.4 176.3
121.2 123.5 129.1 138.1
103.5 105.8 110.7 115.4

TIME= .48 HRS T AVE=144.6 F POWER= 7.8 WATTS ENERGY= 8.7 W-HR
TEMPERATURE ARRAY
168.4 169.1 171.0 176.9
128.9 131.1 135.2 144.1
113.3 115.7 120.3 124.5

TIME= .56 HRS T AVE=149.5 F POWER= 6.7 WATTS ENERGY= 9.3 W-HR
TEMPERATURE ARRAY
170.0 170.6 172.2 177.3
135.7 137.5 142.3 149.2
122.1 124.4 128.6 132.3

TIME= .64 HRS T AVE=153.7 F POWER= 5.6 WATTS ENERGY= 9.8 W-HR
TEMPERATURE ARRAY
171.3 171.9 173.3 177.1
141.7 143.5 147.6 153.5
129.8 131.9 135.7 139.0

TIME= .72 HRS T AVE=157.3 F POWER= 5.0 WATTS ENERGY=10.2 W-HR
TEMPERATURE ARRAY
172.5 173.0 174.2 176.0
146.8 148.5 152.1 157.2
136.6 138.5 141.9 144.7

TIME= .80 HRS T AVE=160.5 F POWER= 4.3 WATTS ENERGY=10.6 W-HR
TEMPERATURE ARRAY
173.5 173.9 175.0 176.3
151.3 152.8 155.9 160.4
142.5 144.2 147.1 149.7

TIME= .88 HRS T AVE=163.2 F POWER= 3.7 WATTS ENERGY=10.9 W-HR
TEMPERATURE ARRAY
174.4 174.8 175.7 176.5
155.2 156.5 159.3 163.1
147.6 149.1 151.7 153.9

TIME= .96 HRS T AVE=165.5 F POWER= 3.2 WATTS ENERGY=11.2 W-HR
TEMPERATURE ARRAY
175.2 175.5 176.3 177.1
159.8 159.5 162.1 165.5
152.0 153.3 155.6 157.5

TIME=1.04 HRS T AVE=167.5 F POWER= 2.7 WATTS ENERGY=11.4 W-HR
TEMPERATURE ARRAY
175.8 176.1 176.8 177.9
161.5 162.8 164.8 167.5
155.8 157.0 159.0 160.6

TIME=1.12 HRS T AVE=169.2 F POWER= 2.4 WATTS ENERGY=11.6 W-HR
TEMPERATURE ARRAY
176.4 176.6 177.3 179.1
164.1 165.0 166.7 169.2
159.1 160.2 161.9 163.3

TIME=1.20 HRS T AVE=170.2 F POWER= 0.0 WATTS ENERGY=11.7 W-HR
TEMPERATURE ARRAY
174.8 175.1 176.0 177.8
166.3 167.0 168.6 171.4
162.0 162.9 164.4 165.6

TIME=1.28 HRS T AVE=170.2 F POWER= 0.0 WATTS ENERGY=11.7 W-HR
TEMPERATURE ARRAY
172.2 172.7 173.8 174.9
167.5 168.2 169.5 170.5
164.4 165.2 166.5 167.4

1
2.64,1
77.,150.,170.,1.,1451.
1.25,.3,.47,.91,129.,61.

Conduction Oven, Heater Bot. & 1/2" Side, 50 W/Can, Frozen Food (Fast)

CONDUCTION OVEN WALL TEMP.=160.0 F POWER DENSITY=1451.0 BTU/HR-FT.SQ

.

FOOD PROPERTIES
TEMP= 0.0 F
K= .97 FROZEN, .26 THAWED
C= .40 .71
L= 91.0
RHO=58.0

TIME= .08 HRS T AVE= 30.1 F POWER= 50.0 WATTS ENERGY= 4.0 W-HR
TEMPERATURE ARRAY

32.0	32.0	32.0	95.3
23.2	23.7	24.9	26.8
19.5	20.1	21.4	22.5

TIME= .16 HRS T AVE= 53.1 F POWER= 40.8 WATTS ENERGY= 7.6 W-HR
TEMPERATURE ARRAY

80.0	82.1	94.1	154.1
31.1	31.2	31.6	32.0
30.1	30.4	30.8	31.2

TIME= .24 HRS T AVE= 66.8 F POWER= 31.9 WATTS ENERGY=10.5 W-HR
TEMPERATURE ARRAY

104.5	110.9	134.6	165.7
32.0	32.0	32.0	52.9
31.9	31.9	32.0	32.0

TIME= .32 HRS T AVE= 76.7 F POWER= 22.5 WATTS ENERGY=12.7 W-HR
TEMPERATURE ARRAY

141.1	142.5	147.7	169.6
32.0	32.0	32.0	66.6
32.0	32.0	32.0	32.0

TIME= .40 HRS T AVE= 82.7 F POWER= 19.4 WATTS ENERGY=14.3 W-HR
TEMPERATURE ARRAY

145.0	146.6	153.8	171.1
32.0	40.7	56.1	72.8
32.0	32.0	32.0	32.0

TIME= .48 HRS T AVE= 90.1 F POWER= 16.6 WATTS ENERGY=15.7 W-HR
TEMPERATU ARRAY

151.5	153.1	157.5	172.2
55.4	57.6	63.9	88.0
32.0	32.0	32.0	32.0

TIME= .56 HRS T AVE= 94.8 F POWER= 14.8 WATTS ENERGY=17.0 W-HR
TEMPERATURE ARRAY

155.0	156.0	159.8	173.0
60.3	61.7	76.2	93.3
32.0	32.0	32.0	32.0

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TIME= .64 HRS   T AVE=101.3 F   POWER= 13.6 WATTS   ENERGY=18.1 W-HR
TEMPERATURE ARRAY
 156.3  157.5  161.7  173.6
  63.1   72.5   85.9  103.4
  32.0   32.0   32.0   52.3

TIME= .72 HRS   T AVE=109.5 F   POWER= 12.2 WATTS   ENERGY=19.2 W-HR
TEMPERATURE ARRAY
 158.4  159.8  163.4  174.3
  79.7   83.9   95.2  112.4
  32.0   32.0   52.0   72.2

TIME= .80 HRS   T AVE=118.3 F   POWER= 10.9 WATTS   ENERGY=20.1 W-HR
TEMPERATURE ARRAY
 160.5  161.7  165.2  175.0
  86.6   92.4  105.9  121.4
  32.0   51.2   75.0   88.3
TIME= .84 HRS   T AVE=122.8 F   POWER= 10.4 WATTS   ENERGY=20.5 W-HR
TEMPERATURE ARRAY
 161.3  162.6  166.1  175.3
  90.2   97.9  111.0  125.5
  50.3   65.4   83.6   95.0
TIME= .92 HRS   T AVE=131.7 F   POWER=  9.0 WATTS   ENERGY=21.3 W-HR
TEMPERATURE ARRAY
 163.3  164.6  168.0  175.9
 104.0  110.4  121.2  133.4
  78.4   86.9   99.2  107.8
TIME=1.00 HRS   T AVE=139.3 F   POWER=  7.7 WATTS   ENERGY=21.9 W-HR
TEMPERATUR ARRAY
 165.9  167.1  169.7  176.5
 116.8  121.7  130.3  140.4
  96.8  102.9  112.1  118.8
TIME=1.08 HRS   T AVE=145.8 F   POWER=  6.5 WATTS   ENERGY=22.5 W-HR
TEMPERATURE ARRAY
 168.2  169.1  171.3  177.1
 127.5  131.3  138.1  146.5
 111.2  115.7  122.3  128.2

TIME=1.16 HRS   T AVE=151.2 F   POWER=  5.5 WATTS   ENERGY=22.9 W-HR
TEMPERATURE ARRAY
 170.1  170.9  172.7  177.5
 136.3  139.2  144.7  151.6
 122.7  126.2  131.9  136.2
TIME=1.24 HRS   T AVE=155.3 F   POWER=  0.0 WATTS   ENERGY=23.3 W-HR
TEMPERATURE ARRAY
 169.3  170.1  172.0  176.6
 143.5  145.3  150.3  156.1
 132.2  135.0  139.5  143.0
TIME=1.32 HRS   T AVE=155.3 F   POWER=  0.0 WATTS   ENERGY=23.3 W-HR
TEMPERATURE ARRAY
 160.1  161.7  164.7  167.5
 148.0  150.0  153.5  156.3
 139.9  142.1  145.5  148.4
TIME=1.40 HRS   T AVE=155.3 F   POWER=  0.0 WATTS   ENERGY=23.3 W-HR
TEMPERATURE ARRAY
 156.7  158.3  161.5  162.5
 150.1  151.9  154.5  156.3
 145.4  147.2  149.9  151.7
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1,64,1
0.,180.,155.,1.,1451.
.97,.26,.4,.71,91.,58.
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Conduction Oven, Heater Bot. & 1/2" Side, 50 W/Can, Thermostabilized Food (Fast)

CONDUCTION OVEN WALL TEMP.=150.0 F POWER DENSITY=1451.0 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 70.0 F
K= .99 FROZEN, .26 THAWED
C= .40 .74
L= 96.0
RHO=58.0

TIME= .04 HRS T AVE= 90.8 F POWER= 41.3 WATTS ENERGY= 1.9 W-HR
TEMPERATURE ARRAY
123.6 123.6 125.0 159.0
71.0 71.0 71.2 80.2
70.0 70.0 70.0 70.1

TIME= .08 HRS T AVE=103.3 F POWER= 22.3 WATTS ENERGY= 3.0 W-HR
TEMPERATURE ARRAY
147.1 147.3 150.2 169.9
77.5 77.6 80.2 96.3
70.4 70.4 70.6 72.3

TIME= .12 HRS T AVE=111.3 F POWER= 16.3 WATTS ENERGY= 3.7 W-HR
TEMPERATURE ARRAY
154.5 154.8 158.0 172.6
86.0 86.6 91.4 107.0
72.2 72.4 73.8 77.5

TIME= .16 HRS T AVE=117.7 F POWER= 13.4 WATTS ENERGY= 4.3 W-HR
TEMPERATURE ARRAY
158.4 158.9 161.9 173.8
93.9 94.9 100.8 114.8
76.0 76.5 79.3 84.1

TIME= .20 HRS T AVE=123.1 F POWER= 11.6 WATTS ENERGY= 4.8 W-HR
TEMPERATURE ARRAY
160.9 161.6 164.4 174.6
100.7 102.3 108.4 121.0
81.0 82.1 86.0 91.2

TIME= .24 HRS T AVE=127.8 F POWER= 10.3 WATTS ENERGY= 5.2 W-HR
TEMPERATURE ARRAY
162.9 163.5 166.1 175.2
106.8 108.7 114.8 126.3
86.8 88.4 92.9 98.1

TIME= .28 HRS T AVE=132.1 F POWER= 9.3 WATTS ENERGY= 5.6 W-HR
TEMPERATURE ARRAY
164.4 165.1 167.5 175.7
112.4 114.4 120.5 130.9
92.8 94.8 99.6 4104.7

TIME= .32 HRS T AVE=136.0 F POWER= 8.5 WATTS ENERGY= 6.0 W-HR
TEMPERATURE ARRAY
165.7 166.4 168.6 176.1
117.5 119.6 125.4 135.1
98.8 101.1 106.0 110.8

TIME= .36 HRS T AVE=139.6 F POWER= 7.8 WATTS ENERGY= 6.3 W-HR
TEMPERATURE ARRAY
166.9 167.5 169.6 176.4
122.2 124.4 129.9 136.8
104.7 107.0 111.9 116.5

TIME= .40 HRS T AVE=142.8 F POWER= 7.1 WATTS ENERGY= 6.6 W-HR
TEMPERATURE ARRAY
167.9 168.5 170.5 176.7
126.6 128.8 134.0 142.2
110.2 112.6 117.3 121.7

TIME= .44 HRS T AVE=145.8 F POWER= 6.5 WATTS ENERGY= 6.9 W-HR
TEMPERATURE ARRAY
168.8 169.5 171.3 177.0
130.6 132.8 137.8 145.4
115.5 117.8 122.4 126.4

TIME= .48 HRS T AVE=148.5 F POWER= 6.0 WATTS ENERGY= 7.1 W-HR
TEMPERATURE ARRAY
169.7 170.3 172.0 177.2
134.4 136.5 141.2 148.2
120.4 122.7 127.0 130.8

TIME= .52 HRS T AVE=151.1 F POWER= 5.5 WATTS ENERGY= 7.3 W-HR
TEMPERATURE ARRAY
170.5 171.1 172.6 177.5
137.9 139.9 144.3 150.8
125.0 127.2 131.3 134.8

TIME= .56 HRS T AVE=153.4 F POWER= 5.1 WATTS ENERGY= 7.5 W-HR
TEMPERATURE ARRAY
171.2 171.8 173.2 177.7
141.2 143.1 147.2 153.2
129.2 131.3 135.2 138.5

TIME= .60 HRS T AVE=155.5 F POWER= 4.7 WATTS ENERGY= 7.7 W-HR
TEMPERATURE ARRAY
171.9 172.4 173.8 177.8
144.2 146.0 149.8 155.3
133.2 135.2 138.8 141.9

TIME= .64 HRS T AVE=157.5 F POWER= 4.3 WATTS ENERGY= 7.9 W-HR
TEMPERATURE ARRAY
172.6 173.0 174.3 178.0
147.0 148.7 152.2 157.3
136.8 138.7 142.1 145.0

TIME= .68 HRS T AVE=159.3 F POWER= 3.9 WATTS ENERGY= 8.1 W-HR
TEMPERATURE ARRAY

173.1	173.6	174.7	176.2
149.6	151.2	154.5	159.2
140.2	142.0	145.1	147.8

TIME= .72 HRS T AVE=160.9 F POWER= 3.6 WATTS ENERGY= 8.2 W-HR
TEMPERATURE ARRAY

173.7	174.1	175.2	176.3
152.0	153.5	156.5	160.9
143.3	145.0	147.9	150.4

TIME= .76 HRS T AVE=162.5 F POWER= 3.3 WATTS ENERGY= 8.4 W-HR
TEMPERATURE ARRAY

2,32,1
70.,180.,170.,1.,1451.
.99,.26,.4,.74,98.,98.

Conduction Oven, Heater Bot. & 1/2" Side, 30 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=[illegible] F POWER DENSITY= 370.6 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .60
L=109.0
RHO=59.0

TIME= .16 HRS T AVG= 35.0 F POWER= 30.0 WATTS ENERGY= 4.3 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 73.0
29.7 29.9 30.2 30.7
28.7 28.9 29.3 29.6

TIME= .32 HRS T AVG= 51.9 F POWER= 28.4 WATTS ENERGY= 9.6 W-HR
TEMPERATURE ARRAY
67.3 69.0 91.1 153.1
32.0 32.0 32.0 32.0
32.0 32.0 32.0 32.0

TIME= .48 HRS T AVG= 69.2 F POWER= 24.2 WATTS ENERGY=13.7 W-HR
TEMPERATURE ARRAY
93.5 103.9 122.0 156.0
32.0 32.0 32.0 91.8
32.0 32.0 32.0 32.0

TIME= .64 HRS T AVG= 82.9 F POWER= 20.6 WATTS ENERGY=17.3 W-HR
TEMPERATURE ARRAY
120.1 136.7 153.2 170.8
32.0 41.4 57.9 81.6
32.0 32.0 32.0 32.0

TIME= .80 HRS T AVG= 95.2 F POWER= 16.0 WATTS ENERGY=20.2 W-HR
TEMPERATURE ARRAY
153.5 155.2 159.5 173.1
58.5 60.9 77.9 97.5
32.0 32.0 32.0 35.4

TIME= .96 HRS T AVG=109.1 F POWER= 13.3 WATTS ENERGY=22.6 W-HR
TEMPERATURE ARRAY
157.2 159.2 163.3 174.3
72.6 81.0 94.9 113.1
32.0 32.0 32.2 73.6
TIME=1.13 HRS T AVG=125.1 F POWER= 10.5 WATTS ENERGY=24.5 W-HR
TEMPERATURE ARRAY
161.3 163.2 166.9 175.6
91.5 101.2 115.4 129.6
49.2 70.4 90.3 101.7

TIME=1.29 HRS T AVE=140.3 F POWER= 7.9 WATTS ENERGY=26.0 W-HR
TEMPERATURE ARRAY

166.0	167.4	170.2	176.1
117.5	123.2	132.3	142.4
97.7	104.5	114.9	121.9

TIME=1.45 HRS T AVE=151.7 F POWER= 5.8 WATTS ENERGY=27.1 W-HR
TEMPERATURE ARRAY

170.1	171.5	172.5	177.6
136.3	139.5	145.3	152.3
122.7	126.6	132.7	137.3

TIME=1.61 HRS T AVE=155.4 F POWER= 0.0 WATTS ENERGY=27.5 W-HR
TEMPERATURE ARRAY

160.5	162.0	165.2	168.1
147.7	149.9	153.6	158.6
139.3	141.8	145.7	148.5

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1
1,120,1
0.,180.,155.,1.,170.6
1.09,.28,.43,.8,109.,59.
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Conduction Oven, Heater Bot. & 1/2" Side, 60 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=160.0 F POWER DENSITY=1741.2 BTU/HR-FT.3

FOOD PROPERTIES
TEMP= 0.
K=1.09 FROZEN, .28 THAWED
C= .43 .80
L=102.0
RHO=59.0

TIME= .08 HRS T AVE= 30.6 F POWER= 60.0 WATTS ENERGY= 4.8 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 100.9
23.6 24.1 25.3 27.1
20.1 20.7 21.9 23.0

TIME= .16 HRS T AVE= 54.0 F POWER= 47.2 WATTS ENERGY= 9.0 W-HR
TEMPERATURE ARRAY
84.7 86.6 95.7 155.0
31.2 31.3 31.5 32.0
30.4 30.6 31.0 31.3

TIME= .24 HRS T AVE= 66.9 F POWER= 35.0 WATTS ENERGY=12.3 W-HR
TEMPERATURE ARRAY
111.2 116.5 135.1 165.7
32.0 32.0 32.0 51.3
31.9 31.9 32.0 32.0

TIME= .32 HRS T AVE= 76.2 F POWER= 24.7 WATTS ENERGY=14.6 W-HR
TEMPERATURE ARRA
141.1 142.2 147.2 169.3
32.0 32.0 32.0 62.0
32.0 32.0 32.0 32.0

TIME= .40 HRS T AVE= 81.1 F POWER= 21.5 WATTS ENERGY=16.5 W-HR
TEMPERATURE ARRAY
144.8 145.7 152.7 170.8
32.0 32.0 52.2 70.9
32.0 32.0 32.0 32.0

TIME= .48 HRS T AVE= 87.9 F POWER= 18.6 WATTS ENERGY=18.1 W-HR
TEMPERATURE ARRA
149.7 151.7 156.7 171.
52.4 55.2 61.8 84.9
32.0 32.0 32.0 32.0

TIME= .56 HRS T AVE= 92.6 F POWER= 16.6 WATTS ENERGY=19.5 W-HR
TEMPERATURE ARRAY
154.2 155.3 159.0 172.7
52.1 69.4 67.4 93.4
32.0 32.0 32.0 32.0

TIME= .04 HRS T AVE= 97.4 F POWER= 15.3 WATTS ENERGY=20.7 W-HR
TEMPERATURE ARRAY
155.8 156.7 160.6 173.3
81.2 83.6 81.2 99.1
32.0 32.0 32.0 40.1

TIME= .72 HRS T AVE=104.4 F POWER= 14.1 WATTS ENERGY=21.9 W-HR
TEMPERATURE ARRAY
156.9 158.5 162.4 173.9
71.9 75.2 82.2 106.7
32.0 32.0 32.0 60.3

TIME= .80 HRS T AVE=112.0 F POWER= 12.7 WATTS ENERGY=23.0 W-HR
TEMPERATURE ARRAY
159.2 160.5 164.0 174.5
82.6 86.3 96.3 118.2
32.0 32.0 50.6 77.2

TIME= .88 HRS T AVE=120.4 F POWER= 11.4 WATTS ENERGY=23.9 W-HR
TEMPERATURE ARRAY
160.9 162.2 165.7 175.1
88.0 94.9 106.1 123.5
36.9 57.8 79.1 91.6

TIME= .94 HRS T AVE=127.3 F POWER= 10.4 WATTS ENERGY=24.6 W-HR
TEMPERATURE ARRAY
162.1 163.6 167.0 175.6
96.5 103.9 116.1 129.5
65.5 76.6 91.6 101.6

TIME=1.02 HRS T AVE=133.1 F POWER= 9.1 WATTS ENERGY=25.4 W-HR
TEMPERATURE ARRAY
164.4 165.8 168.7 176.2
108.6 115.4 125.3 136.5
86.6 94.1 105.0 112.7

TIME=1.10 HRS T AVE=141.8 F POWER= 7.8 WATTS ENERGY=26.1 W-HR
TEMPERATURE ARRAY
166.7 167.8 170.4 176
120.9 125.4 133.3 14 .7
102.3 107.8 116.2 122.4

TIME=1.16 HRS T AVE=147.5 F POWER= 6.6 WATTS ENERGY=26.6 W-HR
TEMPERATURE ARRAY
168.8 169.7 171.3 177.2
130.3 133.3 140.2 148.
114.8 119.0 125.7 130 1
.7

TIME=1.26 HRS T AVE=152.4 F POWER= 5.6 WATTS ENERGY=27.1 W-HR
TEMPERATURE ARRAY
170.5 171.3 173.0 171.6
136.1 140.2 146.1 152.8
125.1 126.4 133.6 138.0

TIME=1.34 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
166.1 167.1 169.7 174.0
144.6 146.3 151.2 156.1
133.6 136.3 140.7 144.1

TIME=1.42 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
159.2 160.8 163.3 166.3
148.1 150.1 153.6 156.1
140.6 142.6 146.3 148.6

TIME=1.50 HRS T AVE=155.1 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
156.3 157.9 160.4 162.0
150.0 151.6 154.4 156.0
145.5 147.3 150.0 151.7

1
1,04,1
0.,160.,155.,1.,1741.2
1.09,.28,.43,.8,102,.59,

Conduction Oven, Heater Bot. & 1/2" Side, 80 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=190.0 F POWER DENSITY=2321.6 BTU/HR-FT.SQ

FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .60
L=109.0
RHO=59.0

TIME= .16 HRS T AVE= 59.9 F POWER= 43.4 WATTS ENERGY=10.6 W-HR
TEMPERATURE ARRAY
111.6 112.1 116.9 161.4
31.5 31.6 31.8 32.0
30.9 31.1 31.4 31.6

TIME= .32 HRS T AVE= 78.3 F POWER= 23.0 WATTS ENERGY=15.5 W-HR
TEMPERATURE ARRAY
144.0 144.6 149.4 170.1
32.0 32.0 42.1 68.0
32.0 32.0 32.0 32.0

TIME= .48 HRS T AVE= 90.4 F POWER= 17.6 WATTS ENERGY=18.7 W-HR
TEMPERATURE ARRAY
152.7 153.9 157.9 172.2
57.0 58.6 64.2 68.0
32.0 32.0 32.0 32.0

TIME= .64 HRS T AVE=100.0 F POWER= 14.8 WATTS ENERGY=21.2 W-HR
TEMPERATURE ARRAY
156.2 157.4 161.5 17..
62.0 71.1 84.9 102.9
32.0 32.0 32.0 47.4

TIME= .80 HRS T AVE=110.4 F POWER= 12.1 WATTS ENERGY=23.4 W-HR
TEMPERATURE ARRAY
160.2 161.3 164.7 174.7
69.5 69.4 102.5 116.6
32.0 36.8 68.2 83.3

TIME= .99 HRS T AVE=135.4 F POWER= 9.0 WATTS ENERGY=25.4 W-HR
TEMPERATURE ARRAY
164.5 165.9 168.3 176.2
110.5 116.0 125.6 136.7
88.0 95.0 105.5 113.0

TIME=1.15 HRS T AVE=147.8 F POWER= 6.6 WATTS ENERGY=26.6 W-HR
TEMPERATURE ARRAY
168.9 169.8 171.8 177.2
130.8 134.2 140.5 148.3
115.5 119.6 126.1 131.8

TIME=1.31 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
166.2 167.2 169.8 174.1
144.9 147.1 151.4 156.2
134.1 136.7 141.0 144.

4

TIME=1.47 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
156.5 158.0 160.5 16
150.3 152.0 154.6 158.2
145.8 147.6 150.2 151.9

TIME=1.63 HRS T AVE=155.3 F POWER= 0.0 WATTS ENERGY=27.4 W-HR
TEMPERATURE ARRAY
154.6 155.7 157.2 158.0
152.6 153.6 155.1 156.0
151.0 152.1 153.6 154.4

1
1,128,1
0.,190.,155.,1.,2321.6
1.09..26,.43..8,109.,5%.,

Conduction Oven, Heater Bottom Only, 50 W/Can, Frozen Food (Slow)

CONDUCTION OVEN WALL TEMP.=180.0 F POWER DENSITY=2224.9 BTU/HR-FT.SQ

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FOOD PROPERTIES
TEMP= 0.0 F
K=1.09 FROZEN, .28 THAWED
C= .43 .80
L=109.0
RHO=59.0

TIME= .08 HRS T AVE= 24.8 F POWER= 50.0 WATTS ENERGY= 4.0 W-HR
TEMPERATURE ARRAY
32.0 32.0 32.0 32.0
22.8 22.8 22.8 22.8
19.1 19.1 19.1 19.1

TIME= .16 HRS T AVE= 48.6 F POWER= 42.3 WATTS ENERGY= 7.9 W-HR
TEMPERATURE ARRAY
110.3 110.3 110.3 110.3
31.0 31.0 31.0 31.0
30.0 30.0 30.0 30.0

TIME= .24 HRS T AVE= 60.7 F POWER= 28.6 WATTS ENERGY=10.8 W-HR
TEMPERATURE ARRAY
133.0 133.0 133.0 133.0
32.0 32.0 32.0 32.0
31.9 31.9 31.9 31.9

TIME= .32 HRS T AVE= 66.0 F POWER= 22.1 WATTS ENERGY=12.8 W-HR
TEMPERATURE ARRAY
143.5 143.5 143.5 143.5
32.0 32.0 32.0 32.0
32.0 32.0 32.0 32.0

TIME= .40 HRS T AVE= 70.1 F POWER= 20.9 WATTS ENERGY=14.5 W-HR
TEMPERATURE ARRAY
145.5 145.5 145.5 145.5
41.0 41.0 41.0 41.0
32.0 32.0 32.0 32.0

TIME= .48 HRS T AVE= 73.3 F POWER= 17.3 WATTS ENERGY=16.0 W-HR
TEMPERATURE ARRAY
151.5 151.5 151.5 151.5
55.4 55.4 55.4 55.4
32.0 32.0 32.0 32.0

TIME= .56 HRS T AVE= 81.6 F POWER= 15.4 WATTS ENERGY=17.3 W-HR
TEMPERATURE ARRAY
154.5 154.5 154.5 154.5
59.5 59.5 59.5 59.5
32.0 32.0 32.0 32.0

TIME= .64 HRS T AVE= 82.7 F POWER= 14.7 WATTS ENERGY=18.5 W-HR
TEMPERATURE ARRAY
155.7 155.7 155.7 155.7
60.9 60.9 60.9 60.9
32.0 32.0 32.0 32.0

TIME= .72 HRS T AVE= 89.8 F POWER= 14.0 WATTS ENERGY=19.7 W-HR
TEMPERATURE ARRAY
156.8 156.8 156.8 156.8
73.6 73.6 73.6 73.6
32.0 32.0 32.0 32.0

TIME= .80 HRS T AVE= 94.3 F POWER= 12.8 WATTS ENERGY=20.7 W-HR
TEMPERATURE ARRAY
158.8 158.8 158.8 158.8
81.6 81.6 81.6 81.6
32.0 32.0 32.0 32.0

TIME= .88 HRS T AVE= 97.9 F POWER= 12.0 WATTS ENERGY=21.7 W-HR
TEMPERATURE ARRAY
160.2 160.2 160.2 160.2
85.6 85.6 85.6 85.6
38.3 38.3 38.3 38.3

TIME= .96 HRS T AVE=107.3 F POWER= 11.4 WATTS ENERGY=22.6 W-HR
TEMPERATURE ARRAY
161.3 161.3 161.3 161.3
93.6 93.6 93.6 93.6
62.9 62.9 62.9 62.9

TIME=1.04 HRS T AVE=116.0 F POWER= 10.4 WATTS ENERGY=23.5 W-HR
TEMPERATURE ARRAY
163.0 163.0 163.0 163.0
103.6 103.6 103.6 103.6
79.0 79.0 79.0 79.0

TIME=1.12 HRS T AVE=123.9 F POWER= 9.3 WATTS ENERGY=24.3 W-HR
TEMPERATURE ARRAY
164.9 164.9 164.9 164.9
112.9 112.9 112.9 112.9
92.0 92.0 92.0 92.0

TIME=1.20 HRS T AVE=130.9 F POWER= 8.2 WATTS ENERGY=25.0 W-HR
TEMPERATURE ARRAY
166.7 166.7 166.7 166.7
121.2 121.2 121.2 121.2
103.1 103.1 103.1 103.1

TIME=1.28 HRS T AVE=137.0 F POWER= 7.2 WATTS ENERGY=25.6 W-HR
TEMPERATURE ARRAY
168.3 168.3 168.3 168.3
128.5 128.5 128.5 128.5
112.7 112.7 112.7 112.7

TIME=1.36 HRS T AVE=142.3 F POWER= 6.3 WATTS ENERGY=26.1 W-HR
TEMPERATURE ARRAY
169.8 169.8 169.8 169.8
134.9 134.9 134.9 134.9
121.1 121.1 121.1 121.1

TIME=1.44 HRS T AVE=147.0 F POWER= 5.5 WATTS ENERGY=26.6 W-HR
TEMPERATURE ARRAY
171.0 171.0 171.0 171.0
140.5 140.5 140.5 140.5
128.4 128.4 128.4 128.4

TIME=1.52 HRS T AVE=151.1 F POWER= 4.8 WATTS ENERGY=27.0 W-HR
TEMPERATURE ARRAY
172.2 172.2 172.2 172.2
145.4 145.4 145.4 145.4
134.9 134.9 134.9 134.9

1
1,64,1
0.,180.,155.,0.,2224.9
1.09,.28,.43,.8,109.,59.

APPENDIX C

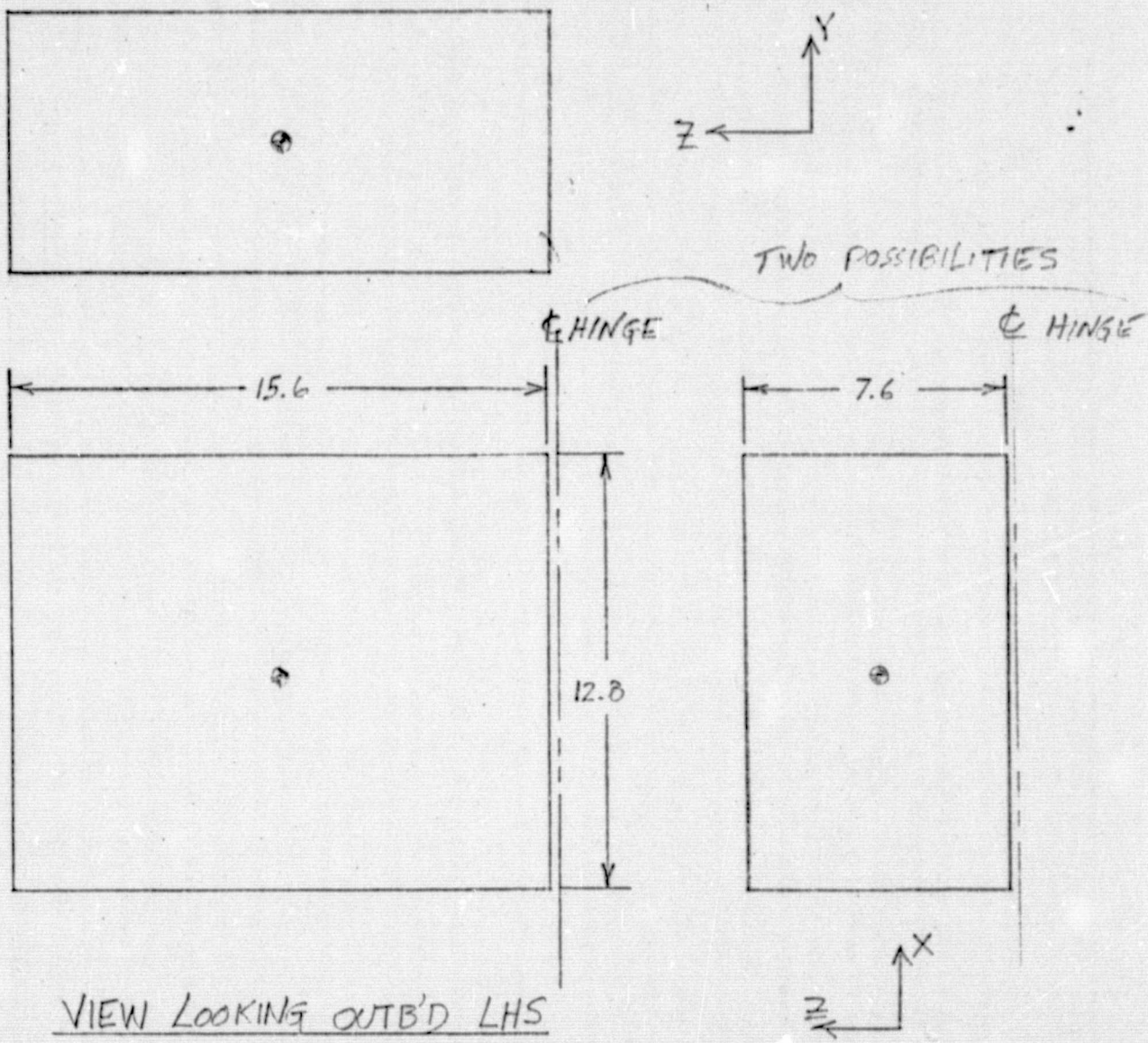
Structural Analysis

STRUCTURAL ANALYSIS: GALLEY OVEN

This analysis is presented as an approach that may be taken to guarantee the structural capabilities of the galley oven when subjected to the conditions as stated in Section 3.3 of the basic report. The results of this analysis is intended to provide the basis for design development of the oven enclosure, door and basic mounting points. As the design progresses, other more pertinent criteria may pre-empt the structural requirements in favor of crew compatibility, manufacturing feasibility or other practical considerations. This analysis will, however, provide a starting point for further development.

The configuration of the convection oven (Ref. dwg. in Appendix) was used for this analysis. The results may be applied to the conduction oven for purposes of this study, as the size, shape and weight are very close.

GALLEY OVEN

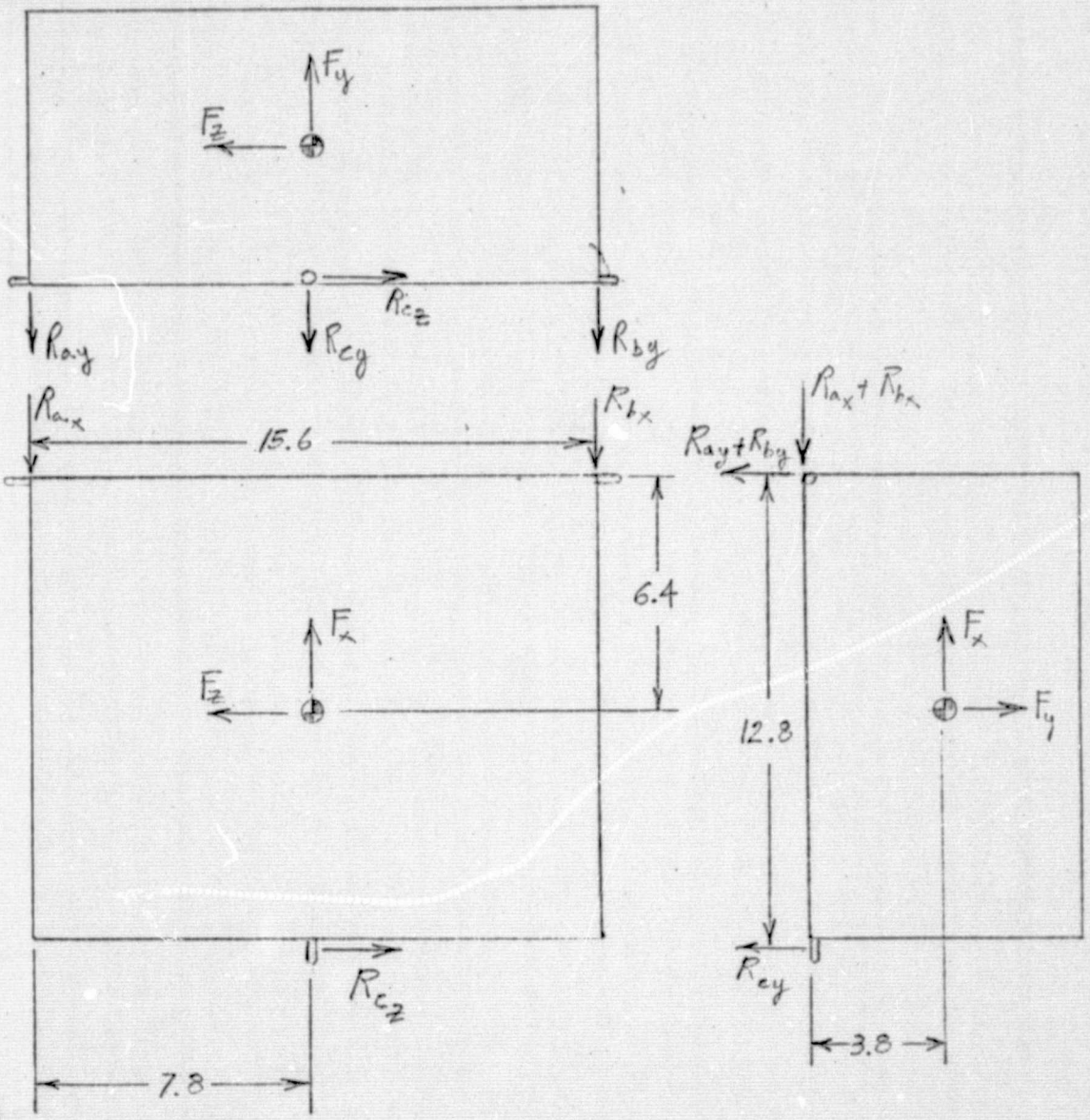


VIEW LOOKING OUTB'D LHS

APPROXIMATE WEIGHT OF OVEN ≈ 20#

C.G. ASSUMED TO BE LOCATED AT GEOMETRIC CENTER

GALLEY OVEN



VIEW LOOKING OUTB'D LHS

SCHEME FOR OVEN SUPPORTED WITH THREE SHEAR PINS OFF THE FRONT FACE

GALLEY OVEN

	$F_x = 1000^{\#}$	$F_y = 1000^{\#}$	$F_z = 1000^{\#}$
R_{ax}	500	0	-410
R_{ay}	-148	250	-244
R_{bx}	500	0	410
R_{by}	-148	250	244
R_{cy}	296	500	0
R_{cz}	0	0	1000

ACCELERATION ± 5.0 g

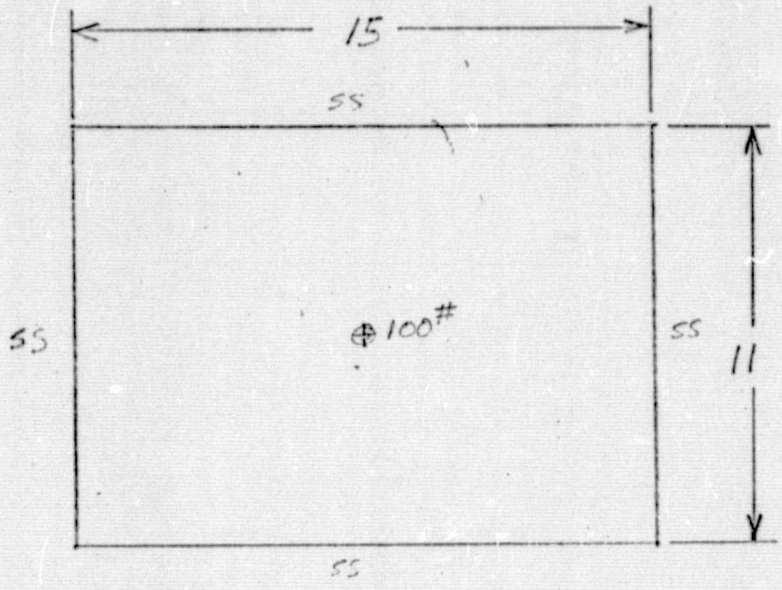
CRASH SAFETY ± 40 g

USE A DYNAMIC MAGNIFICATION FACTOR OF 10

ULT LOAD AT CG = 20 × 5 × 10 = 1000 #

OVEN SIDES FOR HANDLING LOADS

USE 100# ULT AT CENTER OF PANEL



REF. ROARK CASE 37 pg 224 $y \leq \frac{t}{2}$ } FOR NO MEMBRANE STRESSES

(at center) $S = \frac{3W}{2\pi m t^2}\left[(m+1)\log\frac{2b}{\pi r_o} + 1 - \beta m\right]$

$y = \alpha \frac{Wb^2}{Et^2}$

$a/b = \frac{15}{11} = 1.4 \qquad \beta = .211 \qquad \alpha = .158$

$m = \frac{1}{.3} = 3.33 \qquad r_o = 0.5$

$$S = \frac{3\times 100}{2\pi (3.33) t^2}\left[(3.33+1)\ln\frac{2\times 11}{\pi \times .5} + 1 - .211\times 3.33\right]$$

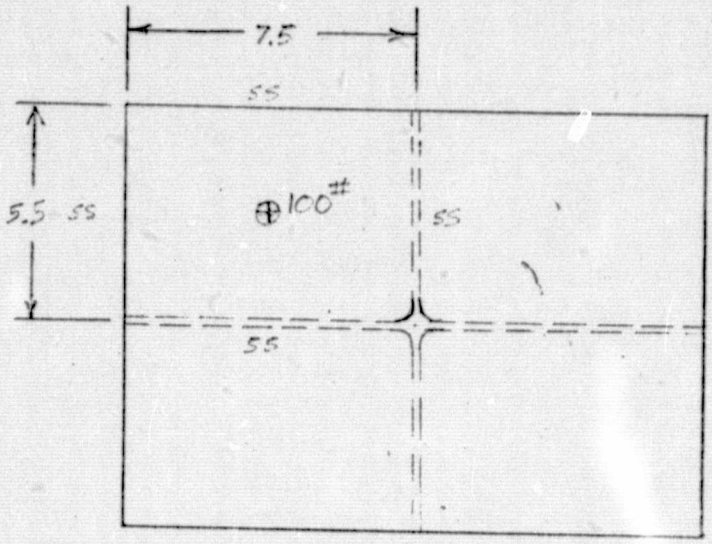
$$S = \frac{14.338}{t^2}(11.429 + 1 - 0.703) = \frac{168.1}{t^2}$$

$$t = \frac{12.96}{\sqrt{S}}$$

$$y = 0.158\,\frac{100\,(11)^2}{10\times 10^6\,(0.047)^2} = 0.087 > \frac{t}{2}$$

MAT'L: 7075-T6 $F_{tu} = 77000$ psi $t_{REQ'D} = \frac{12.96}{\sqrt{77000}} = 0.047$

OVEN SIDES CONT'D



$r_o = 0.5$

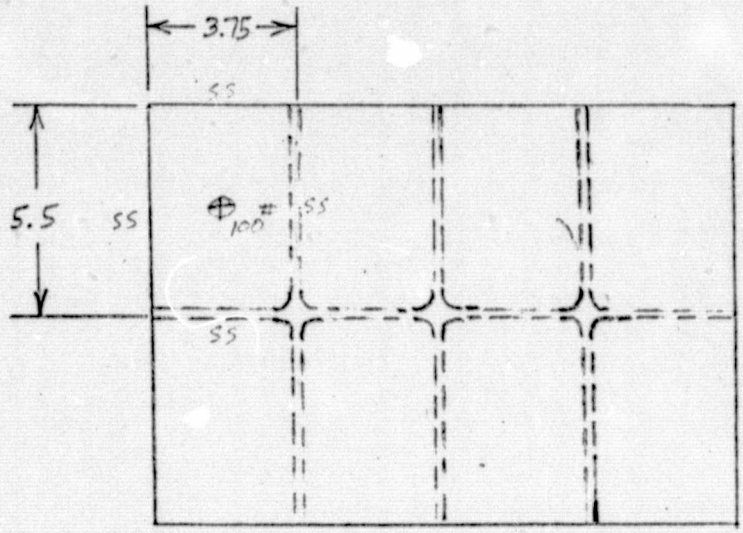
$a/b = \frac{7.5}{5.5} = 1.4 \qquad \beta = .211 \qquad \alpha = .158$

$$S = \frac{3 \times 100}{2\pi \times 3.33\, t^2}\left[(3.33+1)\ln\frac{2\times 5.5}{\pi \times .5} + 1 - 0.211 \times 3.33\right]$$

$$t = \frac{11.18}{\sqrt{S}} \qquad t_{REQ'd} = \frac{11.18}{\sqrt{77000}} = 0.040$$

$$y = 0.158\,\frac{100\,(5.5)^2}{10\times 10^6\,(0.040)^2} = 0.030 > \frac{t}{2}$$

OVEN SIDES CONT'D



$r_o = 0.5$

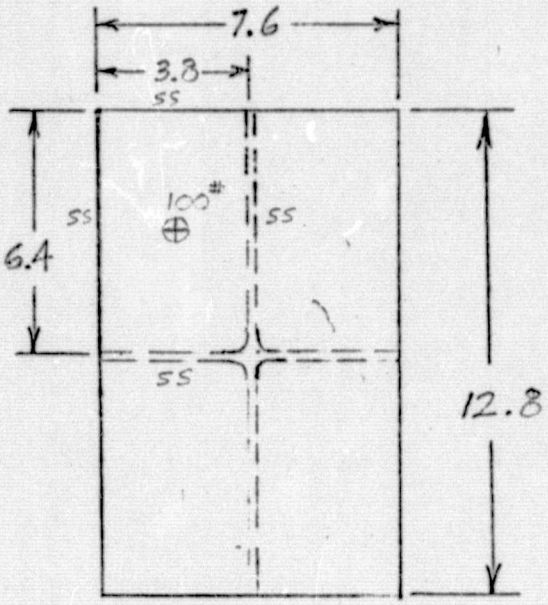
$a/b = \frac{5.5}{3.75} = 1.5 \qquad S = .17 \qquad \alpha = .165$

$$S = \frac{3 \times 100}{2\pi \times 3.33 \, t^2}\left[(3.33+1)\ln\frac{2 \times 3.75}{\pi \times .5} + 1 - 0.17 \times 3.33\right]$$

$$t = \frac{10.16}{\sqrt{5}} \qquad t_{REQ'd} = \frac{10.16}{\sqrt{77000}} = 0.037 \qquad \text{USE } \underline{0.04}$$

$$y = .165\frac{(100)(3.75)^2}{10 \times 10^6 \times (.037)^2} = 0.017 < \frac{t}{2}$$

FRONT & BACK



$r_o = 0.5$

$a/b = \frac{6.4}{3.8} = 1.7$ $\quad \beta = 0.10 \quad \alpha = .174$

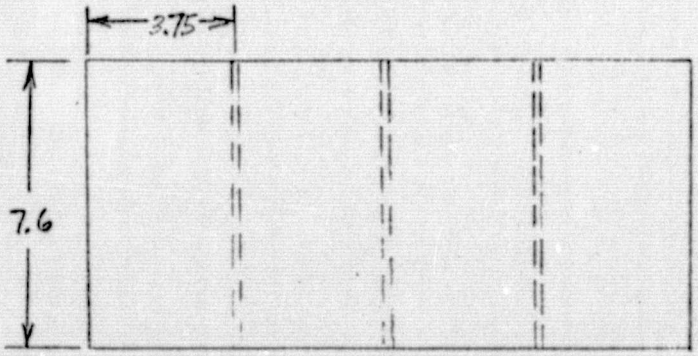
$$S = \frac{3 \times 100}{2\pi \times 3.33\ t^2}\left[(3.33+1)\ln\frac{2\times 3.8}{\pi \times .5} + 1 - 0.10 \times 3.33\right]$$

6.83

$$t = \frac{10.3}{\sqrt{S}} \qquad t_{REQ'd} = \frac{10.3}{\sqrt{77000}} = 0.037 \quad \text{USE } 0.04$$

$$y = .174\,\frac{(100)(3.8)^2}{10\times10^6\times(.037)^2} = 0.018 < \frac{t}{2}$$

OVEN TOP & BOTTOM



$r_o = 0.5$ $\quad a/b = \frac{7.6}{3.75} = 2$

$\beta = 0.042 \quad \alpha = .1805$

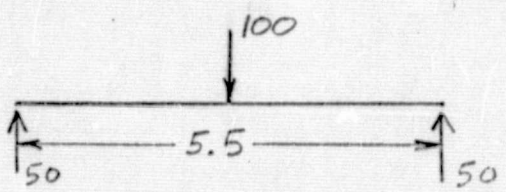
$$S = \frac{3\times100}{2\pi\times3.33\ t^2}\left[(3.33+1)\ln\frac{2\times3.75}{\pi\times.5} + 1 - .042 \times 3.3\right.$$

$$t = \frac{10.46}{\sqrt{S}} \qquad t_{REQ'd} = \frac{10.46}{\sqrt{77000}} = 0.0$$

USE 0.0

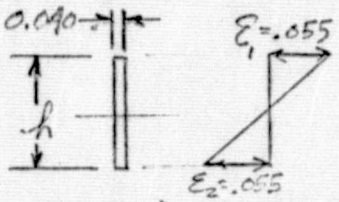
$$y = .1805\,\frac{(100)(3.75)^2}{10\times10^6\times(.038)^2} = .018 < \frac{t}{2}$$

DESIGN OF RIBS



$M_{MAX} = 50 \times \frac{5.5}{2} = 137.5$ IN-#

USING COZZONE'S METHOD TO FIND ULT BENDING STRENGTH (REF. CB.2 BRUHN)



EFFECTIVE SECTION FOR RIB

MAT'L: 7075-T6 SHT

$f_m = 77000$

$f_o = 70000$

K=1.5

$F_b = 77000 + 70000(.5) = 112000$ psi

$I/c = \frac{th^2}{6} = 0.00667\, h^2$

$M_{ULT} = 137.5 = 0.00667\, h^2 \times 112000$

$h = \underline{0.43}$"

FOR $h = 0.50$

$I/c = \frac{0.040}{6}(.5)^2 = 0.00167$

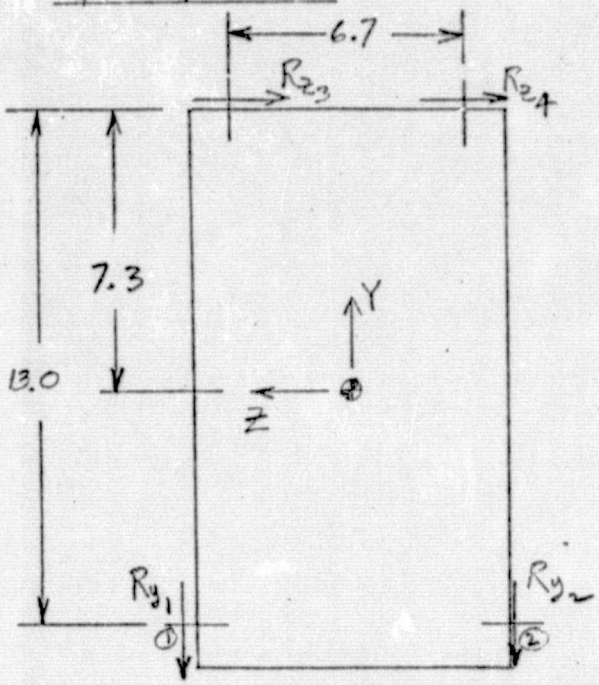
$M_{ULT} = 0.00167 \times 112000 = 187$ IN-#

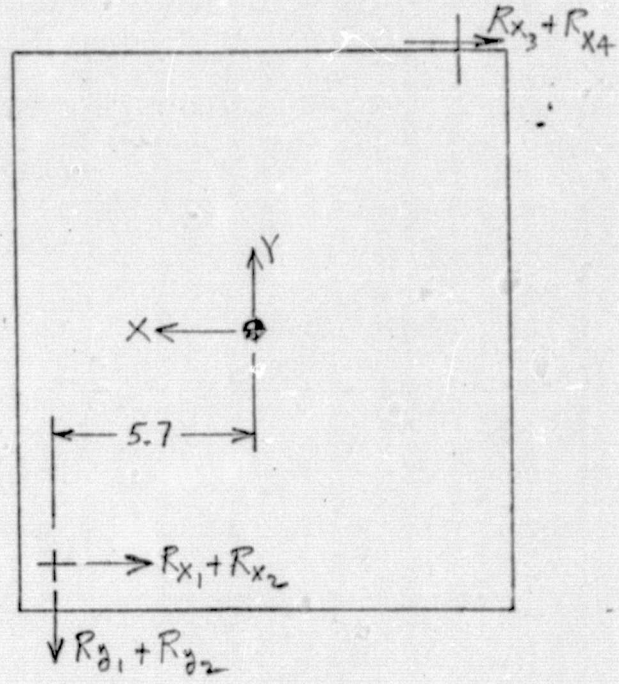
$M_{MAX} = \frac{Pl}{4}$

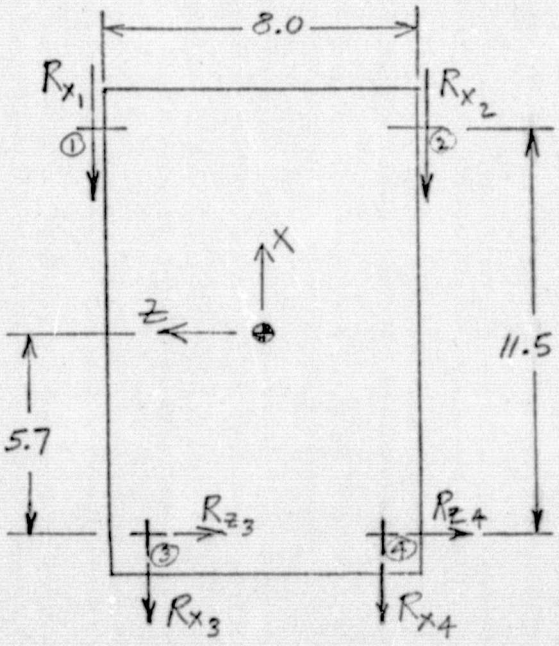
SIDES $\frac{100 \times 6.4}{4} = 160$ IN-#

TOP & BOTTOM $\frac{100 \times 7.6}{4} = 190$ IN-# Say OK

GALLEY OVEN







WEIGHT OF OVEN ≈ 20#

C.G. ASSUMED TO BE LOCATED AT THE GEOMETRIC CENTER.

VIEW LOOKING OUTBRD LHS

GALLEY OVEN

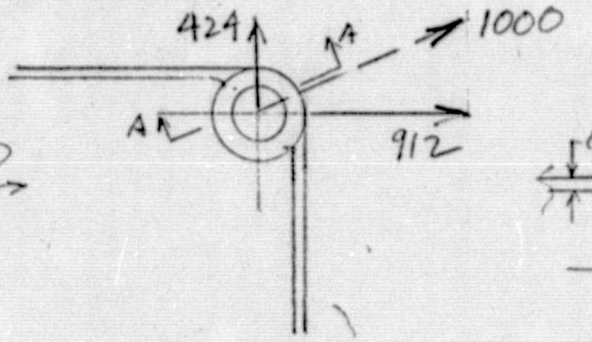
ULT LOAD = 9's × Mag × ult. = 5 × 10 × 20 = 1000#

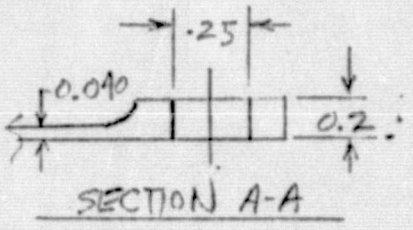
	$F_x = 1000^{\#}$	$F_y = 1000^{\#}$	$F_z = 1000^{\#}$
R_{x1}	250	-220	-424
R_{y1}	0	500	912
R_{x2}	250	-220	424
R_{y2}	0	500	-912
R_{x3}	250	220	-350
R_{z3}	0	0	500
R_{x4}	250	220	350
R_{z4}	0	0	500

∴

UPPER LUGS

MAT'L: 7075-T6





SECTION A-A

$e/D = 1.65$ $d = .25$ $D/w = .3$ $e = 0.41$ $e/w = .5$ $K_t = 4.0$ } REF. GSSD 3.1.4

REF GRUMMAN STRUCTURAL DESIGN DATA 2.4.1 } $\frac{f_{br.ol}}{F_{tu}} = 1.45$ $f_{br_{all}} = 1.45 \times 77000 = 111600$ psi

$$f_{br} = \frac{1000}{0.25 \times .20} = 20{,}000 \text{ psi}$$

$$MS = \frac{111600}{20000} - 1 = \underline{\text{AMPLE}}$$

CHECK PIN SHEAR STRENGTH

MAT'L: ANNEALED 6AL-4V 1/4" ϕ PIN

$F_{su} = 80000$ psi

$$f_s = \frac{1000}{\frac{\pi}{4} \times (.25)^2} = 20400 \text{ psi}$$

$$MS = \frac{80000}{20400} - 1 = \text{AMPLE}$$

CHECK FATIGUE

$A_{NET} = .20\,(.82 - .25) = 0.114$

$f_{t_{NET}} = \frac{1000}{.114} = 8800$ psi $\quad f_{max} = 4.5 \times 8800 = 39500$ psi

IF $f_{max} \leq 30000$ psi, $f_{min} = 0$ } REF. MIL HDBK 3-228

THEN CYCLES TO FAILURE $\rightarrow \infty$ }

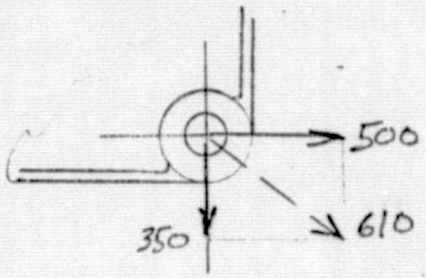
$K_N = 1 + \frac{K_t - 1}{1 + \sqrt{\ell/r}} = 1 + \frac{3.0}{1 + \sqrt{1.017/.125}} = 3.2$ } REF. MIL HDBK 3-228

$f_{max} = K_n \times f_{t\,net} = 3.2 \times 8800 = 28200$ psi

$28200 < 30{,}000$

$n \longrightarrow \infty$ NUMBER OF CYCLES TO FAILURE.

LOWER LUGS



$e/D = 1.65$ $d = .25$

$e = 0.41$ $t = .125$

$K_t = 4.5$

CHECK FATIGUE

$A_{NET} = .125(.82 - .25) = 0.071$

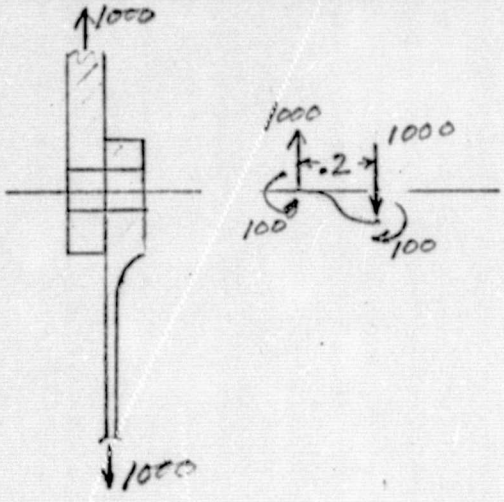
$f_{t_{NET}} = \frac{610}{0.071} = 8600$ psi

$f_{max} = 8600 \times 3.2 = 28000$ psi

$28000 < 30{,}000$

$n \longrightarrow \infty$ NUMBER OF CYCLES TO FAILURE

CHECK FATIGUE OF PIN



1/4" ϕ 6AL-4V ANNEALED PIN

$$I/c = \frac{\pi D^3}{32} = \frac{\pi \times (\frac{1}{4})^3}{32} = .0015$$

$$f_b = \frac{100}{.00153} = 65400 \text{ psi}$$

$f_{max} = 65{,}400$ psi $\quad f_{min} = -65400$ psi

$R = -1.0$

$n \approx \infty$ CYCLES TO FAILURE } REF. MIL HDBK 5-86